NATIONAL SCIENCE FOUNDATION AUTHORIZATION, 1970

HEARING

BEFORE THE

SPECIAL SUBCOMMITTEE ON THE NATIONAL SCIENCE FOUNDATION

OF THE

COMMITTEE ON LABOR AND PUBLIC WELFARE UNITED STATES SENATE

NINETY-FIRST CONGRESS

FIRST SESSION

ON

S. 1856

TO AUTHORIZE APPROPRIATIONS FOR ACTIVITIES OF THE NATIONAL SCIENCE FOUNDATION, AND FOR OTHER PURPOSES

S. 1857

TO AUTHORIZE APPROPRIATIONS FOR ACTIVITIES OF THE NATIONAL SCIENCE FOUNDATION PURSUANT TO PUBLIC LAW 81-507, AS AMENDED

MAY 7, 1969

Printed for the use of the Committee on Labor and Public Welfare

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SPECIAL SUBCOMMITTEE ON THE NATIONAL SCIENCE FOUNDATION

EDWARD M. KENNEDY, Massachusetts, *Chairman*

CLAIBORNE PELL, Rhode Island
THOMAS F. EAGLETON, Missouri
WINSTON L. PROUTY, Vermont
PETER H. DOMINICK, Colorado

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APPENDIX

NATIONAL SCIENCE FOUNDATION AUTHORIZATION, 1970

WEDNESDAY, MAY 7, 1969

U.S. SENATE,
SPECIAL SUBCOMMITTEE
ON THE NATIONAL SCIENCE FOUNDATION
OF THE COMMITTEE ON LABOR AND PUBLIC WELFARE,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:35 a.m., in room 4232, New Senate Office Building, Senator Edward M. Kennedy (chairman) presiding.

Present: Senators Kennedy (presiding), Pell, Eagleton, Prouty, and Saxbe.

Also present: K. Dun Gifford and Roy H. Millenson.

Senator KENNEDY. The subcommittee will come to order.

This is the first time the Senate has been privileged to conduct authorization hearings for the National Science Foundation, as required by last year's revision of the National Science Foundation Act. These hearings, along with those recently conducted by the Subcommittee on Science, Research, and Development of the House, mark an historic monment in the course of scientific affairs, and they signify that American science has finally come of age. As with any coming of age, this means added responsibilities as well as enlarged opportunities. Before introducing our distinguished witnesses today, I should like to speak for a moment on the meaning of this new maturity for American science.

First, let me say that by American science, I do not refer to the wealth of scientific knowledge produced or utilized in America. Scientific knowledge knows no national boundaries; the spirit of scientific inquiry has always been international in scope. I mean by American science the many thousands of American scientists and engineers engaged in the creation and application of scientific knowledge throughout the Nation—in schools, in government, in industry, and in the expanding nonprofit sector of our society. This scientific enterprise is—in the words of Dr. Jerome Wiesner, provost of the Massachusetts Institute of Technology—currently in "a state of disarray." This condition is the result of budgetary cuts for research at universities and national research centers; the imposition of expenditure ceilings; a reduction in support for graduate science education; and deferral of the acquisition of many vital research facilities and much-needed equipment. It is essential that scientific activity be protected as much as possible from detrimental disruptions and dislocations, due to wide fluctuations in

funding patterns. Scientific research is a long-term investment in the Nation's future which requires stability of support if it is to realize its vast potential benefits for human betterment.

But scientists must recognize also that the propitious period of unquestioning and ever-expanding support for science, which started in the 1940's, has finally ended in the mid-1960's. While I deplore the difficulties the scientific enterprise has encountered in recent years—and while I intend to do what I can to help remedy these problems—I do not view the fundamental turn of events with misgivings, for it signifies to me that science has come of age, and is adjusting to the added responsibilities that come with increased maturity.

Scientific leaders must accept the responsibility to justify the support science receives from society; not in terms of specific research projects, for these can be judged only on their merits by scientific peers, but in terms of the overall national investment in scientific research and education, and what this investment means to the Nation and to our children and their children after them. Similarly, the youth of our Nation must be much better educated in science and its significance to their lives; and much more highly motivated to participate in—or serve as intelligent witnesses to—the wonders of scientific achievement.

Moreover, while basic research must continue as the core of scientific creativity—and its support must remain the primary mission of the National Science Foundation—our scientific leaders must expand their imagination to devise improved ways of applying scientific knowledge more extensively and effectively to the pressing problems of society.

Finally, our scientific leadership is faced with an enlarged and extremely difficult responsibility, which it has barely begun to meet. This is the problem of scientific and technological priorities: of choosing and periodically recasting the proper balance among the Nation's investments in research, development, and engineering; between basic and applied research; and among disciplines, fields, and subfields of science and engineering. As long as available funds and the expansion in scientific manpower kept pace with scientific progress, these problems never became overly pressing.

But now, and through the foreseeable future, the potential for scientific progress far exceeds the anticipated funds and manpower we can expect to be available. The recurring necessity for hard choices among competing programs and projects—all of which may be desirable in themselves—will characterize the scientific enterprise of tomorrow. Insofar as such choices were necessary in the past, they were based largely—and generally successfully, I might add—on the personal judgment of our scientific leaders. But the complexity of choice confronting us today and in the future precludes reliance on ad hoc choices on the basis of personal judgment. It is imperative for our scientific leadership to promote the development of effective methodology and meaningful criteria for allocating scientific resources on a more scientific basis, while at the same time identifying and delineating those factors and decisions to be determined within a broader context of public policy by the Nation's political leadership.

I repeat that I do not view these enlarged responsibilities with misgivings; for I am confident that the scientific community can meet these challenges successfully and in a manner which will enhance the strength of our scientific enterprise while bestowing its manifold benefits more widely among all segments of our society.

At the start of the modern scientific era, Sir Francis Bacon—who contributed so greatly to the empirical, experimental approach to scientific inquiry—served his society also as Lord High Chancellor. Similarly, that greatest of scientific theorists, Sir Isaac Newton, also served his nation as Master of the Mint. I am not suggesting that scientists today seek public service in other fields, although I am sure they would be most welcome to do so. But I am suggesting that an intimate, powerful partnership between science and society is currently emerging—a partnership which will simultaneously serve to strengthen the scientific enterprise and to multiply the benefits accruing to society. I believe that these first authorization hearings in the Senate for the National Science Foundation will contribute to that process by expanding and enhancing the dialogue between the scientific community and the Congress.

The 9 days of hearings before the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics were extremely comprehensive and detailed in their discussion of NSF's current programs. We do not propose in these hearings to duplicate the excellent record developed by Chairman Emilio Daddario and his subcommittee, but rather to make full use of that record in highlighting certain important aspects of NSF's programs, placing particular emphasis on the Foundation's expectations and plans for the future. Considering the vast and profound changes science has precipitated in our civilization in recent decades, it is only prudent to anticipate the possibility of accompanying changes of significance in the structure of the scentific enterprise itself and in its relationship to society. I hope the hearings commencing today will serve to illuminate these and other related issues of importance.

Our distinguished witnesses today are Dr. Leland J. Haworth, Director of the National Science Foundation, and Dr. Philip Handler, Chairman of the National Science Board and President-elect of the National Academy of Sciences.

We are particularly pleased you have come here today to pursue these issues with us, and we look forward to an extremely stimulating interchange.

Before we start, Dr. Handler, I should like to take this occasion to thank you and your colleagues on the National Science Board for your recent report to the Congress entitled "Toward a Public Policy for Graduate Education in the Sciences." This report marks an excellent beginning to the Board's national policies for the promotion of basic research and education in the sciences. I am confident the report will prove to be a valuable contribution to policy development for this important area, as well as for education in general. We look forward to the receipt of further Board reports in the future, and I hope you will be able to touch on the important implications of this report in your remarks this morning.

I would like to note for the record that Ellis Mottur, a senior scientist at George Washington University, has been of invaluable assistance to the subcommittee in preparing for these hearings.

This subcommittee has under consideration two separate bills, S. 1856, introduced by Senator Prouty, and S. 1857 which I introduced. I will ask them both to be printed in the hearing record, for comparison.

(The bills referred to follow:)

91st CONGRESS
1st Session

S. 1856

IN THE SENATE OF THE UNITED STATES

April 18, 1969

Mr. Prouty introduced the following bill; which was read twice and referred to the Committee on Labor and Public Welfare

A BILL

To authorize appropriations for activities of the National Science Foundation, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby authorized to be appropriated to the National Science Foundation for the fiscal year ending June 30, 1970, to enable it to carry out its powers and duties under the National Science Foundation Act of 1950, as amended, and under title IX of the National Defense Education Act of 1958, out of any money in the Treasury not otherwise appropriated, $487,000,000.

Sec. 2. Appropriations made pursuant to authority provided in section 1 shall remain available for obligation, for

expenditure, or for obligation and expenditure, for such period or periods as may be specified in Acts making such appropriations.

SEC. 3. Appropriations made pursuant to this Act may be used, but not to exceed $2,500, for official reception and representation expenses upon the approval or authority of the Director, and his determination shall be final and conclusive upon the accounting officers of the Government.

SEC. 4. In addition to such sums as are authorized by section 1 hereof, not to exceed $3,000,000 is authorized to be appropriated for expenses of the National Science Foundation incurred outside the United States to be paid for in foreign currencies which the Treasury Department determines to be excess to the normal requirements of the United States.

SEC. 5. This Act may be cited as the "National Science Foundation Act of 1969".

91st CONGRESS
1st Session

S. 1857

IN THE SENATE OF THE UNITED STATES

April 18, 1969

Mr. Kennedy introduced the following bill; which was read twice and referred to the Committee on Labor and Public Welfare

A BILL

To authorize appropriations for activities of the National Science Foundation pursuant to Public Law 81–507, as amended.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby authorized to be appropriated to the National Science Foundation for the following programs:

(1) Support of scientific research, $248,600,000.

(2) Computing activities in education and research, $22,000,000.

(3) Institutional support of science, $69,000,000.

(4) Science education support, $112,500,000.

(5) Science information activities, $13,000,000.

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(6) International cooperative science activities, $2,000,000.

(7) Planning and policy studies, $2,900,000.

(8) Program development and management, $17,000,000.

SEC. 2. (a) When so specified in an appropriation Act, any amount appropriated pursuant to this Act may remain available without fiscal year limitation.

(b) Appropriations made pursuant to this Act may be used, but not to exceed $2,500, for official reception and representation expenses upon the approval or authority of the Director, and his determination shall be final and conclusive upon the accounting officers of the Government.

SEC. 3. Notwithstanding any other provision of this Act—

(a) no amount appropriated pursuant to this Act may be used for any program deleted by the Congress from requests as originally made to either the House Committee on Science and Astronautics or the Senate Committee on Labor and Public Welfare;

(b) no amount in excess of 5 per centum of the amount appropriated for any program pursuant to this Act may be used for any program in excess of the amount actually authorized for that particular program by section 1; and

(c) no amount appropriated pursuant to this Act may be used for any program which has not been presented to or requested of either such committee, unless—

(A) a period of thirty days has passed after the receipt by the Speaker of the House of Representatives and the President of the Senate and each such committee of notice given by the Director or his designees containing a full and complete statement of the action proposed to be taken and the facts and circumstances relied upon in support of such proposed action; or

(B) each such committee before the expiration of such period has transmitted to the Director written notice to the effect that such committee has no objection to the Foundation proceeding with the proposed action before the expiration of the thirty days.

SEC. 4. Section 14 of the National Science Foundation Act of 1950, as amended by Public Law 90–407 (82 Stat. 360), is amended by adding to the end thereof the following new subsection:

"(i) Notwithstanding any other provision of law, the authorization of any appropriation to the Foundation shall expire (unless an earlier expiration is specifically provided) at the close of the third fiscal year following the fiscal year

for which the authorization was enacted, to the extent that such appropriation has not theretofore actually been made."

Sec. 5. In addition to such sums as are authorized by section 1 hereof, not to exceed $3,000,000 is authorized to be appropriated for expenses of the National Science Foundation incurred outside the United States to be paid for in foreign currencies which the Treasury Department determines to be excess to the normal requirements of the United States.

Sec. 6. This Act may be cited as the "National Science Foundation Authorization Act of 1970".

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., May 2, 1969.

Hon. RALPH YARBOROUGH,
Chairman, Committee on Labor and Public Welfare,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This is in further reply to your letter of April 21, 1969, requesting the comments of the National Science Foundation on two bills, S. 1856 and S. 1857, to authorize appropriations for the National Science Foundation.

Both the above bills would authorize appropriations in an amount totalling $487,000,000 (plus $3,000,000 in excess foreign currency funds) for the National Science Foundation for the fiscal year ending June 30, 1970. Such authorization is required by Section 16(a) of the National Science Foundation Act of 1950, as amended (42 U.S.C. § 1875).

While enactment of either bill would result in authorization of the same total amount, the Foundation favors enactment of S. 1856. This bill provides for authorization of a total sum only, without the breakdown into program categories and the restrictions on transfer of funds between categories required by Sections 1 and 3 of S. 1857, thereby ensuring greater flexibility and more effective administration of the Foundation's funds.

The Bureau of the Budget has advised us that there is no objection to the submission of this report from the standpoint of the Administration's program.

Sincerely yours,

LELAND J. HAWORTH,
Director.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., May 2, 1969.

Hon. RALPH YARBOROUGH,
Chairman, Committee on Labor and Public Welfare,
U.S. Senate, New Senate Office Building,
Washington, D.C.

DEAR MR. CHAIRMAN: This is in reply to your requests of April 21, 1969, for reports on S. 1856 and S. 1857, bills "To authorize appropriations for activities of the National Science Foundation."

While both S. 1856 and S. 1857 would authorize the same level of appropriations for the National Science Foundation, section I of S. 1856 would stipulate a single dollar amount without subdivision by program or the imposition of other restrictions on the allocation of funds among activities of the Foundation. The specific needs, priorities, and opportunities in basic science may not be predictable at the time an authorization bill for the Foundation is proposed and acted upon. Hence, it is desirable for the Foundation to retain a high degree of flexibility, and S. 1856 would provide such flexibility. In light of the above, we recommend favorable consideration of S. 1856, which is in accord with the program of the President, in lieu of S. 1857.

Sincerely yours,

WILFRED H. ROMMEL,
Assistant Director for Legislative Reference.

Senator KENNEDY. Senator Prouty.

Senator PROUTY. Mr. Chairman, I have a brief statement.

The members of this special subcommittee are, I am sure, in agreement as to the immense contributions of the National Science Foundation and the need for Congress to properly authorize this Foundation's continued endeavors.

The enactment of Public Law 90–407 last July broadly expanded the responsibilities of the Foundation, and by providing for an annual report from the National Science Board, improved communications between the legislative and executive branches. It is my hope that this

special subcommittee and these hearings will further improve these communications.

On April 18, I introduced for the administration a bill under the new act to authorize appropriations for the Foundation for fiscal year 1970. In introducing the administration's bill to authorize appropriations for activities of the National Science Foundation, I remarked that it seems desirable to provide for authorization for the general purposes of the Foundation.

This is, I think, most important, in that it provides the Foundation the maximum degree of flexibility to use its resources to best fulfill its mandate. To lock in the authorizations for appropriations would seem unduly restrictive.

I am pleased to note that the House Subcommittee on Science, Research, and Development has unanimously ordered reported to the full Committee on Science and Astronautics a bill containing authorization for the general purposes of the Foundation. I recommend we take a similar course by favorably recommending the approach taken in the present administration's measure.

I anticipate that these hearings will be of immense informational value as we explore the performance and promise of the National Science Foundation.

Thank you.

Senator KENNEDY. Thank you very much, Senator Prouty.

I want to invite both Dr. Haworth and Dr. Handler, if they will be kind enough, to come up together to the witness table.

Your voices have been very clear and consistent since we last met about the importance of assistance to science, and scientific policy, and I would like to commend both of you for your efforts and your interest in this behalf.

Dr. Handler, perhaps we might hear from you first as the Chairman of the Governing Board of the National Science Foundation. You may proceed as you wish.

STATEMENT OF DR. PHILIP HANDLER, CHAIRMAN, NATIONAL SCIENCE BOARD, AND PRESIDENT-ELECT, NATIONAL ACADEMY OF SCIENCES

Dr. HANDLER. Thank you very much, Senator Kennedy, Senator Prouty.

It is not my purpose in being here to defend the itemized budget which the National Science Foundation has offered for your consideration. Dr. Haworth has a prepared statement and will discuss the details of that budget in due course. For my part, I hope to set the stage for what he has to say and for the words of subsequent witnesses.

I should say that the budget request is fully endorsed by the National Science Board. We have gone over its construction with the Director and his staff as that work was in progress. We fully concur in their recommendations to you, while regretting the constraints that shape that budget. We are convinced that the Naional Science Foundation could quite properly and wisely utilize a substantially larger appropriation in the coming fiscal year, in the national interest. But, we are aware of and understand the constraints which shape that budget.

In this regard, I am reminded of a small story. There was a very distinguished Viennese pharmacologist named Otto Loewi who came to the United States in the forties and served as professor emeritus of pharmacology for some years at New York University. When he was in his mid-eighties, he received an invitation from one of our larger pharmaceutical houses to give a seminar at their laboratories not far outside of New York City. The letter of invitation went on to point out that, unfortunately, their finances were such that they could not provide an honorarium, but they would provide his transportation.

Dr. Loewi replied to the effect that he was deeply grateful for their generous invitation, but, unfortunately, he had had a very serious case of the flu recently and he did not find it possible to accept. He hoped that one day, when his health and their finances were in better shape, they would ask him back.

That is our position, gentlemen. I hope that, similarly you will ask us back when our national financial circumstances are also in better shape.

It is almost platitudinous, now, to say that science is the hallmark of the culture of these United States, the hallmark of the 20th century. Yet, it is no less true. Science is surely the leverage which our society has developed for shaping its future and for making the condition of man, at home and abroad, better than we have ever known it in the past.

History certainly bears out that contention. Today our Nation is stronger, healthier, and wealthier than it ever has been before, very largely because we have learned how to apply the findings of science for development of technologies which enrich all aspects of American life.

As a working scientist, I personally might wish that we could justify the scientific endeavor exclusively on its cultural merits, since all of us can enjoy the intellectual concepts of science and what these reveal of the nature of the universe and the nature of man. But I am well aware of the fact that it is most unlikely that the American people would support science even on the scale which we now do, on that basis alone. Nor is that necessary· All about us are the products of science and its derived technology. We spend more on science as a nation than we do on art, largely because science has demonstrated that it is useful to our society. We have every reason to think that it will continue to be so in the future.

As our Nation goes about supporting fundamental research at the universities, Federal laboratories, and nonprofit institutions, the scientific community can offer no guarantees, no promises, that tomorrow's findings will be translated into direct human applications. But the corpus of scientific understanding has doubled in each decade for more than a century. That fact, of itself, is evidence that our ignorance has exceeded our understanding by a wide margin. We have every reason to believe that that is still true at the present time.

I know of no reason to believe that the scientific findings of tomorrow will be any less useful than those of yesterday. That is an article of faith. It is the only one we can offer to you as we ask your support of the fundamental scientific endeavor.

Now, in the years since World War II, there have been several stimuli to Federal support of science: The advent of nuclear fission,

with its implications for defense and for nuclear power for domestic purposes; the widespread public conviction and hope that, by scientific understanding, we might improve medical care; Sputnik and its challenge, a challenge which was entered upon partly for military reasons, partly because of the promise for improved meteorological findings, but in a large measure for national prestige, for the battle for men's minds around the globe in this demonstration of what a free society could do in competition with one which is not free. In this regard, the leadership that American science has taken in the world of science generally has indeed enhanced our national prestige, and has contributed demonstrably to our national security on that ground alone.

For my part, I am very proud to be a citizen of a country whose Congress thought it appropriate to a create an agency like the National Science Foundation, an agency dedicated exclusively to the assurance of our national strength in science. This is our substitute for the classical mechanism in which a bountiful royalty occasionally found it useful to sponsor research by an unusually gifted individual, In our country, we have institutionalized the support of science and we have done so much to the national benefit on a large scale and long-term basis.

Today, those earlier stimuli have not lost their validity. Research and development still are the keys to our improved national defense. The health of the Nation has been improved, but we have a long way to go. It is true that there are many, who today, ask that the Federal effort concentrate on improved mechanisms for the delivery of medical care to those who require it in all walks of life. I can only applaud such efforts. This is a task that very seriously needs doing. But I ask that those who must find the funds to support that enterprise also understand that the best of medical care, which we hope to make available to all Americans, still leaves a great deal to be desired—not because of the limitations of those who must deliver that care, but the limitations of the armamentarium we have placed in their hands The reasons for our current mortality tables, the fact that the ancient killers of man are still the present killers of man, derive very largely from our ignorance, not from any ineptness of those who practice medicine. Accordingly, I hope that we will continue to underpin and expand the research enterprise which will, hopefully, one day give us better understanding and the tools required to deal with man's ancient enemies, the diseases with which he is beset.

Scientifically, I am sure that the best of space science remains to be done. But there are now new challenges which face our Nation, as valid as the old challenges and probably more difficult to deal with.

Population control is surely the largest single issue facing mankind. From the standpoint of the technical aspects of population control, we are really not very well equipped. We do not even understand the tools that we have at the moment, such as the intrauterine devices. Our knowledge of reproductive physiology has turned out to be pitifully scanty now that we have turned to it for assistance in this matter.

Our agriculture is perhaps the most successful endeavor our country has ever attempted; truly it has served us, and the other nations of the world, well. But as we look to the future with a population growth which is inescapable, at least to the turn of this century, we will require a markedly enhanced agricultural capability, both at

home and abroad. Yet the scientific underpinnings of that endeavor, if not already exhausted, have been pushed almost to their limits.

It is clear that our demands for water are quite likely to limit the kind of civilization we can have and enjoy in the next century and centuries to come. We simply must learn how to make available relatively cheap pure water on a vast scale if life is to be as good in the future as it has been in the past.

We will require new sources of power, but we know where to find them. Probably these are to be found, in the long haul, from the power of nuclear fission. And having learned now how to deal with very low-grade ores, it is likely that a moderately improved technology will remove the limits from our civilization now imposed by the availability of power.

All of us are constantly aware of water and air pollution as problems. It is true that the air of our major cities is probably cleaner today than it was 50 years ago, in the soft coal burning era, but it is also true that we have much to do. As yet, the chemistry and the physics of what happens in the air pollution is not very well understood. The processes which led to water pollution by virtue of the dumping of the effluvia of every city and town into our main streams are well known to us. But the biological processes which then occur in those streams are not equally well known. There has been only one compelling demonstration that we can reverse the process of eutrophication as far as I know.

This happened at Lake Washington, just outside Seattle, where some years ago Professor Edmondson of the University of Washington became aware of the fact that Lake Washington had entered upon the deadly cycle which had ruined other streams and lakes. He was aware of the fact that there was an increase of algae at the surface, and that the oxygen content of the deeper water was diminishing. Every other stream and lake which had been so affected had been put on a seemingly irreversible path in which the algae grew thicker, the oxygen content grew lower, the waters became murky, the amount of life below the surface decreased, and finally the body of water simply became a useless mess which can not support life and is unhealthy for human beings.

By first undertaking the political effort necessary so that all the communities fronting on Lake Washington combined to pool their resources, they were able to turn this situation around. Today, people again swim in Lake Washington, and the water is available as a water resource for the surrounding area.

Thus, it can be done. It requires, first, political initiative, then technological understanding. We have much to do in gaining that technological understanding, but this history does offer genuine hope that that all too common situation, which we have all deplored, can indeed be turned around.

We have other needs which are obvious. We are badly in need of a system of high-speed ground transportation. We are badly in need of cheap, low-cost, esthetically pleasing housing. And we require a technological basis for its construction, a basis which is not available at the present time.

In saying all this, I must warn that, to some extent, we have come to the natural limits, at least in the sense that there are some things we

already do as well as they can be done, even in theory. By that I mean that most of us fly around the globe at a velocity just below the speed of sound and we cannot hope to go very much faster. There are some who have gone into orbit, and a privileged few who have escaped. But if we are to stay on this planet, we really can't hope to travel very much faster than we already do.

All of us communicate with each other at the speed of light by television, by radio, and by telephone, and it can't be done any more rapidly. The speed of light is limiting and it is pointless to think about any attempt to accelerate that process.

Computers have added a new dimension to human affairs. Computers have been developed so rapidly that they, too, are now limited, literally, by the speed of light. The current generation of computers is as fast as they can be. They can have larger memories built onto them, but they cannot compute any faster without finding some way to compress them. It is the speed of light which limits the time between events which happen in a modern computer. So here, too, we have come to a kind of limit.

Our personal lives for the most part today are not limited by the availability of power, but for our civilization and its requirements for tomorrow, it is quite obvious that we could be—unless nuclear power becomes available on a very large scale. The breeding reactor gives every sign of becoming available in the relatively near future and if perfected could indeed solve that problem for us. Nevertheless, I am quite sure that as in the past, science will offer surprises. The unpredictable will occur again and each time it does, it will offer us a new handle on the world in which we live, a new opportunity to make life better.

That is surely true in the biological world where the kind of natural limitations I have just mentioned for the physical world are not yet compelling. There is nothing about the biological world but the nature of man himself in which we can see genuine limitations. It is true that there are limits to the amount of arable soil on which we can plant crops. But in many places the intensity of cultivation can certainly be increased very, very markedly. And there is no reason why we cannot look forward to entirely new crops, which do not exist at the present time.

For all of the success of our agriculture, it is rather surprising that no new major foodstuff has been introduced into the human economy during recorded history. Everything that we eat, our precivilized ancestors ate as well. To be sure, we have modified them. The corn we eat or feed to hogs is genetically derived from the corn the Indians were eating when our ancestors came here, but it has come a long way. This is also true of wheat and every other major crop. It is true of the fowls we eat, of the beef we breed. Nevertheless, no entirely new foodstuff has actually been introduced into the economy.

Occasionally, I find that fact rather deeply troublesome because mankind, across the planet, is so terribly dependent on just a handful of major crops—corn, rice, and wheat. The thought of a virus pandemic to which no strain of those plant species would be resistant is a spectre which will haunt us as long as we continue to remain so utterly dependent on those three crops. Accordingly, a serious endeavor scanning the available strains of plants, looking for new opportunities for man's cultivation, I think, is called for over a long period.

There is another class of problem, however, for which we as a Nation are just not prepared. These are the social problems of our society, the problems which are on the front pages of the newspapers every day. Presumably, those problems belong in the purview of that disparate group of disciplines called the social sciences. It is an unfortunate fact that the social sciences are not ready to deal with those problems. One could, if one wished, state that the blame, if blame there need be, is our society's, that we did not support the social sciences early enough and encourage and nurture them when they needed it so that the social sciences and social scientists could be of genuine assistance in this hour of need. I doubt that that is true in point of fact. Every discipline has to grow at its own rate and in its own time. Its concepts, thoughts, understanding, facts if facts there are, have to be built up in a rational, orderly way. I doubt that, if we had tried to force-feed the social sciences in the last 50 years, it would have made much difference. I doubt that the social sciences would have been very significantly stronger than they are today, very much more able to deal with the problems of American society in 1969. But I do think that the portents are that they will be ready tomorrow. They have learned how to think quantitatively, how to gather quantitative data; they have sharpened their analytical tools, which are quite different from the analytical tools of physical or biological science, and now these are available.

As far as I can tell, the social scientists are about ready to understand our society in a way that they have certainly not done in the past.

In the hope that that is true, and it is almost imperative that it be true, I certainly commend the support of the social sciences to Members of the Congress.

There is one particular aspect of the request from the Science Foundation this year which I commend to you in this regard. This is the request for the support of a limited number of multidisciplinary centers, each of which shall be focused upon one specific problem of society. This is not entirely a new invention. There are already a few such centers around the country. Some of them have been decidedly successful, others much less so.

But the problems of society can't be handled in a purely disciplinary fashion. The problems do not come in nice little packages of which one can say: "This one is sociology, that is economics, or that is political science." Each problem goes across the board in our society; simultaneously, they are sociological, political, economic, they are technical, and involve engineering. We would like the opportunity to package representatives of each of these disciplines under circumstances where they could profitably and to their mutual benefit work together on specific, designated problems. Such experiments have been undertaken before with limited success. It is our hope that, with experience, such institutions will learn how to cope with these problems and be much more useful to our society than they have been in the past.

Certainly, if we are to have a set of national action programs addressed to our social ills, programs that are based on genuine understanding, rather than pragmatic hopes arising out of the acuteness of need, we must do something of this sort as a way to get the kind of understanding which is required.

Senator KENNEDY. Dr. Handler, I want you to feel free to continue with your splendid testimony. Sometime or other, I would like to come back and explore in greater detail with you somewhat more precisely what you have in mind in this area, because I know the members of this subcommittee, and generally, the full Labor Committee, have jurisdiction over a number of different kinds of programs which are trying to help us meet some of our social problems more effectively and more dramatically, with greater energy. Of course, I am sure you are very much aware of the growing feeling and concern about the reordering of priorities in a way to come to grips with the social problems that exist in the country today. I am sure that many of our friends, and your friends, are going to want to know, with this order of requests for funds, somewhat more precisely why you feel that you are going to be better equipped to undertake these efforts.

For example, in urban problems, in the urban areas which you indicate in your budget, how will your work differ from the studies being done by the urban coalition, for example? How can we be assured we are not going to have an overlap, a duplication in these various efforts?

Dr. HANDLER. I do not know whether I can speak to these questions with sufficient understanding, Senator Kennedy. The thought in this request is that these centers be organized on and at university campuses. The senior persons who would work there would be members of the university faculty, working with graduate students, undergraduates, postdoctoral fellows. The university as it has existed classically is not well equipped to deal with multidisciplinary problems, yet, as I said a moment ago, the problems of society just do not come in neat disciplinary pigeonholes. Our hope is to create an arrangement in which a university that has already sequestered so much of the talent required will then generate a new way of doing its business, in which diverse natural and social scientists, and engineers and so forth, live together in close quarters, talk to each other directly and about the problems of mutual interest.

I cannot be very concerned with the problem of overlap and duplication, Senator Kennedy. The Congress frequently is, and I understand that. But I have rather complete confidence in the communications network which exists among those engaged in such studies. They do know what each other is doing. They will not deliberately, voluntarily duplicate precisely what each other is doing.

In other areas of science, it is almost imperative that there are what appears to be duplication as the only way to check the validity of what is reported out by one working unit. Science itself insists on this.

I do not necessarily believe what I read about some aspect of biochemistry until I can check it, to make sure it is so, in my own laboratory. I do not see why the social sciences should be less scientific in that regard.

We really need not be concerned seriously, for so modest a program, with this problem of duplication. There are so many problems and they are so acute that the more brains we can put on them, the sooner we can hope to cope with them.

And the problems will not wait. They are worse daily if what I read in the newspapers is so.

Senator KENNEDY. I suppose—and I want you to continue—I suppose one of the concerns that we have been very much aware of is, of course, the student activities which have taken place in a number of our great universities. Some of the teachers, even in the social sciences, are spending more time in research and less time in the classroom. I do not know whether we are going to be funding programs which will take some of the very distinguished and renowned professors and teachers out of the classrooms, putting them to work, as worthwhile as these studies might be, in this field of research.

Senator PROUTY. Mr. Chairman, could I follow that up?

Senator KENNEDY. Sure.

Senator PROUTY. Recently I had the opportunity to visit with some undergraduate students at one of our major universities. One of their principal concerns was the fact that they seldom see the university's outstanding scholars and noted professors. Their courses are conducted by graduate students. They were genuinely concerned by this instructional arrangement.

I just wanted to follow Senator Kennedy's question up along that line.

Dr. HANDLER. That is a difficult question to deal with out of complete knowledge, gentlemen. For my part, I suspect that in a general way, that allegation is a canard which was no more or less true 50 years ago than it is today. It was true when I went to college and graduate school. I do not see any reason why it should be that much different today.

It is not that I am defending the idea that professors should do research while graduate students teach. No such thing. But the fact is that we do not have the total faculty manpower, we can't find them, and if we did, could not pay for them, to do all the teaching our students think should be done by the senior faculty. It is physically not possible. In a general way, courses in the university now are organized in such fashion that the professor delivers lectures, and sees students on request. But in addition, there are numerous conferences or quiz sessions, by whatever term they may be known on any given campus or in any given course, and these are conducted by the graduate students because they are the available manpower.

Moreover, most graduate students are very knowledgeable. They are bright and eager; they are well aware of the problems of their disciplines and although they may not yet enjoy the status or reputation of the professor, one should not denigrate their teaching capabilities, which are quite real. And in fact, at the present moment, we should point out that one of the problems besetting American universities in consequence of the declining enrollments in some areas of science because numbers of bright students have recently decided that science is not "relevant," and because of the operation of the draft, is that many universities are having a very serious time meeting their teaching responsibilities for lack of those very graduate students.

I do not know any university where the professors simply enjoy life in a full-time career in research. For my part, I teach medical and graduate students and in addition teach a course for undergraduate students for which no provision is built into the university budget. The faculty of my department, which is strongly research-oriented, nevertheless has voluntarily expanded our teaching commitments on

numerous occasions. I can vouch for similar situations on many a campus.

Senator KENNEDY. I am sure you are not trying to convey the impression that—as gifted or as talented as some graduate students are—they are any substitute for men of academic achievement, learning, and experience who provide inspiration at many of the great universities. I take issue with your observation that because—fortunately or unfortunately—this was happening 50 years ago, professors are justified in continuing this practice today. Judging from my own contacts with young people, I do not think what was good enough 50 years ago—or even 5 years ago—is good enough today.

Dr. HANDLER. With the later statement, I fully concur, Senator. But again just as you and the Congress must decide what to do with the Nation's resources and how to deploy these best in the national interest, so, too, the university must decide how to use the faculty. I know of no university that thinks the faculty shall all go into the laboratories and not be seen by their students. There is no such place. But we do have to decide how to use the faculty time most effectively.

The professor who is teaching a few graduate students in the laboratory is teaching just as surely as he is when he is in a classroom with 25 undergraduates. Indeed, it may be the most meaningful teaching he does. The students who are rebelling are unaware of that process because they have not yet come sufficiently along in the system to participate in it.

In our society, the generation of new knowledge and understanding is a function of the university equivalent to the classical function of transmitting, storing, and codifying old knowledge and understanding. If we markedly restrict the research function of the faculty, either our society will stagnate or erect a new institutional form for the conduct of research—and then attract away from the campus those very scholars we all wish to place before the eager minds of our future citizens and leaders. Accordingly, some reasonable compromise is necessary. I agree that there may be occasional, rare abuses, full-time research professors, but these really are so rare as to be insignificant. In any case, where the system is abused, it should be corrected. But if the compromise we have evolved is understood, society will accept the contribution of the professor in colloquy with a few graduate students as part of his contribution, just as truly as is that he makes with undergraduates, and will also accept the need for a substantial research effort as well. It is just that rich mixture of effort which keeps our faculty intellectually alive and, at least potentially, stimulating to their students. And it is just this phenomenon which has attracted such large numbers of the brightest young people from Europe, Asia, Africa, and South America to our universities at all levels, undergraduates, graduate students, and post-doctoral fellows. Surely it is ironic that just as our universities are under attack, students and faculty are joining in many other countries to reform their universities so as to resemble ours!

Senator KENNEDY. I understand that. At the college I attended, however, there were large numbers of students, anywhere from 400 to 700, attending social science lectures. In addition they had the tutorial period and also special kinds of meetings with graduate students. If you remove the professor from those courses, even if only occasionally,

and divert those energies into even as worthwhile an effort as the proposed interdisciplinary program, I think——

Dr. HANDLER. Senator, we do not mean to take the professor out of that classroom at all. He is still to be on campus and still to do that kind of teaching. At the same time, we want to give him the equivalent of a laboratory for the natural sciences, a building in which he meets with other knowledgable folks and deals with real problems and engages in a kind of simulation of the real world. That is where he will do additional laboratory equivalent teaching with advanced undergraduate students and graduate students, and postdoctorals. It is a way we hope we can strengthen the educational system, not weaken it, while equipping the Nation to deal with its social problems.

Senator PROUTY. Mr. Chairman, I would like to read into the record a brief paragraph from the Senate committee report on the Higher Education Act of 1965:

> The committee has noted that there has been a tendency in recent years for college teachers to devote less time to class instruction and to personal counseling of students than previously, factors which have become more evident as institutions of higher education have become larger and more impersonal. While recognizing the importance of research—which this committee itself has encouraged in other legislation—we nevertheless are hopeful that this Act will serve to encourage the expert and the teacher to devote more time to the classroom and the student. We look to an equitable balance between the research and the teaching and between the outside lecture platform or publishing house and the classroom.

Dr. HANDLER. I am aware of that statement, Senator. I have never seen the documentation that proves the university is teaching less. I know and can document from my own experience that, at least at Duke University, we are teaching more and not less. The fact that undergraduate students are dissatisfied stems not so much from the change in behavior of the faculty as it does from the change in preparation and the expectations of the undergraduate student. The undergraduate student arrives at our university today far better prepared than I did when I went to college. They arrive as better prepared students than any were when I went to graduate school, than I and my fellows were when we went to college. Indeed, in part this is a tribute to the success of the course content improvement programs of the National Science Foundation.

It is the change in students, not the behavior of the faculty, which accounts for their dissatisfaction. We can applaud that change. They want to learn, they are eager to learn. And their expectations for personal contact with the faculty far exceed those of graduate students two decades ago. It is not so much a change in the preparation and expectations of the faculty but of the students. And the faculty remains limited in numbers. Graduate enrollments grow and society's need for research grows as well.

Senator KENNEDY. Doctor, I hope you gather from this questioning that one thing of which all of us are very much aware is the extraordinary progress which this Nation has made in scientific and technological fields. One question which I have been repeatedly asked while traveling around my own State and visiting other parts of the country is why we are capable of orbiting the moon, but incapable thus far of depolluting our streams and our air. I know the proposed interdisciplinary program is an attempt to be responsive to very serious concerns by Members of Congress and generally by people through-

out the country. I know that NSF hopes through this program to make some contributions to resolution of our pressing social problems, by drawing on the special skills and interdisciplinary potential available in many of the great universities around the country. So I support these efforts and applaud the energies of the National Science Board in trying to come to grips with these problems. I hope our discussion helps you better understand the kinds of questions which those of us supporting the program will be asked as we face others who may not be as sympathetic as we.

Dr. Handler. Senator, may I make one additional statement? As I said earlier, we have on the university campuses sequestered from the rest of society those persons most knowledgeable with respect to the kind of problems which confront society. They are called the faculty. What we are trying to do is make them maximally useful to this Nation. Now, that means that we must ask that they deal with the real world in a real setting in a meaningful way. It is there where we will get the best teaching as well.

The reason medical schools are as competent at their task as they really are is that medical schools are usually congruent with hospitals. The student learns about medicine not in the abstract but in the real world of the hospital. He sees real patients and deals with them in a meaningful way. Our hope was that on university campuses, the study of sociology, political science, anthropology, economics, demography, as these relate to society, can be made more meaningful, less abstract, less abstruse, more connected with the real problems; if you can still tolerate the word, to assure "relevance." This is what we are hoping to do in creating problem oriented centers. This is trying to do for the social sciences what has been done much more effectively for the natural sciences and yet more effectively in the professional setting of a medical or engineering school in the past.

Well, we have used up much of our time, so if I may, I will move on fairly rapidly.

It is fair, then, to ask where we stand in the national scientific endeavor. As I mentioned earlier, there seems to be evidence of disenchantment with science in our society. We know that there has been a fall off in enrollments of students interested in physics and chemistry very sharply in the last two years. This apparently largely relates to an increasing focus of interest on man-related rather than nature-related study on the part of students. At the same time, science and its derived technology is blamed for some of the ills of our society—pollution, automation, and our capability for destroying mankind all seem to be problems which are blamed on the success of science. And there is a half truth in that. It is true that pollution is created by human endeavors using technology. It is true that we have these capabilities for destroying one another.

The solution, however, is not to blame science but to reckon with the fact that we have not done well as a Nation in learning how to handle the technological capabilities which have been developed to enrich life for all of us. Those capabilities are there and if our society is willing to pay the price, we can certainly clean up our atmosphere, we can certainly clean up our waters. We can generate new and meaningful forms of employment for all of our people if we try. That will require

not less but more science, more technology, and the result will be yet a better world for all of us to live.

Although, therefore, there are some of our young people who think that for the moment, science is not relevant, my own feeling is that it is more relevant, more necessary than it ever has been before.

The sciences themselves are at once both in difficulty and submerged in their own success. They are in difficulty because we have more young scientists, more ideas than we can support. Our current limitations of funds make it necessary to forego numbers of new ventures in science, opportunities which we have not yet tried, some of which are rather expensive. Yet it is true that science thrives by taking advantage of new opportunities. We must have an infusion of new ventures from time to time, to pace the entire endeavor.

At the same time, all around the United States, carefully, with Federal funds, we have been nurturing institutions which are now ready to take their places in the total scheme of things in the performance of scientific research and science education, quite as the Congress has repeatedly requested. These institutions find themselves unable to make further progress for lack of funds. So, in these terms, we are deeply troubled, even though we understand the constraints which have brought about this situation. And it is not my intention to be unreasonable in requesting a sheltered position in which the national scientific endeavor is utterly unaffected by the major forces in our national life. But I do hope that you will recognize the nature and magnitude of our dilemma. Two decades of deliberate action by the Federal Government, with full encouragement and support by the Congress, have developed an intricate network of laboratories and facilities and brought in large numbers of the finest young minds our Nation can boast. Universities have fully committed themselves to their part in the endeavor. Then, abruptly, commencing in fiscal year 1967, financial support was brought to a plateau. Last year, the appropriation to NSF was reduced by 20 percent from the previous year. Meanwhile, inflation erodes the purchasing power of available dollars; universities are embarrassed by their commitments, new young investigators can find no means of implementing their ideas; our graduate schools deliver more young talent who had been lured into such training at a happier time when the national purpose seemed more evident; and high school and college students, viewing the congressional attitude toward science evident in the appropriation to NSF are turned away from careers in science, fortified in the thought that "science is not relevant." Has not the time come to reverse this trend?

On an other scale, however, I must note that science is flourishing. It was never bigger, never more alive, never more successful than it has been in this decade or at this moment. In my testimony before the House committee, I have tried to document that at some length. The hour has gone and it would not be appropriate for me to take the time here to do so. I would be delighted to submit it for the record if you would like me to.

Senator KENNEDY. As I mentioned earlier, there was a great deal of excellent testimony presented before the Daddario subcommittee in the House. We have a very close working relationship with that subcommittee. Perhaps our staff should review with you those portions of that testimony most pertinent to our discussion.

Dr. HANDLER. I meant to give you a new set of examples of scientific success and I would be glad to supply those for the record, if you wish.

Senator KENNEDY. Fine. That might be very helpful.

Dr. HANDLER. May I conclude with a different set of remarks, then?

Senator KENNEDY. Sure.

Dr. HANDLER. Because we have been talking about the universities, and since the programs of NSF are implemented at the colleges and universities, I would like to talk about them for just a moment, if I may.

As you know, our universities are in deep trouble. At the moment, there is no university known to me which is not in dire distress.

What I am asking for is that our universities be given the opportunity to work themselves out of the problems in which they find themselves. The problems are real enough. Our students' requests have at their roots genuine problems of American society, as well as genuine problems in the role of the university in our society. I think many of the complaints are contrived, many of them are not as relevant as the students seem to find them, and some are deliberately destructive. But it is easy to distinguish which is which. My hope is that there shall be no great "backlash" from the American people or their Congress in which, out of chagrin, disgust, repugnance, or impatience for what goes on, on the campus it is decided not to support the sciences, either through the National Science Foundation or through other agencies. If we go that route, then the youngsters of the SDS will have been successful beyond their wildest dreams. They will really have brought down the house as some of them have tried to do.

It is imperative, it seems to me, that this Nation support the universities in this hour of need. Universities are the key to the vitality of the entire American scheme of things. And Federal support of the academic science endeavor has been the most stable—and stabilizing—element in the university. Let us not default on the American dream because of the actions of a small minority.

Senator KENNEDY. Dr. Handler, what is the role of the university in this? You say that we in the Congress ought to continue to support these kinds of programs, that if we do not, we are really granting a victory to the SDS and those who want to destroy the institutions. What do you feel is the role of the universities—the administration and the faculty—in attempting to cope with both legitimate and illegitimate demands of many of these students?

Dr. HANDLER. I think the problems are internal to the university. Each university will have to learn to cope with its problems in its own time.

I very much doubt that the external forces of our society can reach in and solve those problems. Because dissident students have brought before the university complaints which contain varying merits of justice, the university has been caught. In recognizing the justice of some of the requests, although not the unfortunate mechanisms by which the complaints are frequently made, the university has occasionally reacted in a somewhat pusillanimous way and overreacted in other instances.

We in the universities have not known where the line should be drawn. It seems to me that we have probably passed or are reaching the crest of such activities, that universities find their paths a little

bit clearer now than they did. Surely, we have had a sufficient number of demonstrations of what not to do. I am not sure where we have had any clear demonstration of what to do. But we probably will have more experiments thrust upon us, whether we want to or not.

I do believe that university administrations, their trustees, and their faculties, will learn how to live with these problems, how to evolve a new form of government for the university, a form in which legitimate requests can be heard and dealt with and the illegitimate requests immediately recognized as such and denied. I think that, shortly, we will find that the forcible seizure of property, the use of abusive language, will no longer be condoned by the powers that be on any campus, it having been demonstrated that that route, turning the other cheek, as it were, does not seem to be successful, it merely breeds the next action of the same kind. I have hopes that, before the next academic year is out, universities will have learned to cope with some of these problems, while avoiding the pitfall of allowing the university to be transformed into an instrument for social actions. I am not at all certain that I know how any external agency, such as the Federal Government, can reach in and change that pattern in a useful way. But I would hate to see our society pull the rug out from under the university while it is struggling with a class of problems it never knew before. No greater calamity could befall American society.

Senator KENNEDY. One of the major problems confronting us in the Congress—and I hope Dr. Haworth might express his view on this as well—is the problem of reviewing national programs with a significant scientific component, such as the current inquiry regarding the ABM system. Obviously, we have within the Senate, committees charged with responsibility to review these kinds of programs and systems and make recommendations, with respect to which we attempt to fulfill our responsibilities and obligations. I wonder what value you feel there may be in the Congress having independent scientific evaluation and advice on various of these programs which require extraordinary expenditures of resources.

Dr. HANDLER. By independent, do you mean external bodies or groups?

Senator KENNEDY. Yes. I am mindful of the suggestion of Dr. Killian not long ago of having a highly competent, independent group take a view of the ABM system and try to provide some independent knowledge and information to those who have the ultimate responsibility in the authorizing and appropriating process in the Congress. Considering the mood of the country regarding review of the military budget, how much value do you place on independent, scientific studies of such programs?

Dr. HANDLER. I have just changed my hat, Senator and am now speaking as President-elect of the National Academy of Sciences. Just over 100 years ago, President Lincoln found that he had a similar problem and, therefore, brought into being a National Academy of Sciences specifically charged with providing that sort of advice on request from the Government. The National Academy of Sciences operates the organization known as the National Research Council, having some 400 committees which provide advice to executive agencies of the Government, and occasionally to the Congress. That is what it exists to do. To my knowledge, the Academy was not asked for an

opinion on the technical aspects of the ABM. If that had occurred, I think the Academy would have responded, limiting its response to an analysis of the technical aspects of the problem—not how deployment of an ABM system might relate to abilities to deal with the Soviet Union in a political context, nor how it might affect the problem of disarmament, but a technical evaluation of the capability of any proposed system. Such advice is the only excuse for the existence of the Academy, and I can promise that we would assemble the most competent scientists and engineers to provide neutral, unprejudiced technical advice.

Senator KENNEDY. Are you then throwing the ball back to the Congress, saying we should have requested such a review from the Academy?

Dr. HANDLER. Yes, sir. That was a pitch for business, I guess.

Senator KENNEDY. In other words, a request for this kind of review would be welcomed, or at least recognized as part of the responsibility of the Academy.

Dr. HANDLER. Yes, sir.

Senator KENNEDY. Well, that is very helpful.

Dr. HANDLER. I think that will conclude my testimony, Senator.

Senator KENNEDY. Thank you, you may supply a statement for the record, if you wish.

(The statement referred to follows:)

May 19, 1969

Dear Senator Kennedy: At the authorization hearing for the National Science Foundation, I offered to extend my statement, documenting some of the recent contributions of science. In view of the subcommittee's interest in the social sciences and their application to societal purpose, particularly by multidisciplinary efforts, may I take this opportunity to introduce to you, for the record, an article by Dr. Henry W. Riecken, President of the Social Science Research Council. This article, which follows, is the clearest, most succinct statement of the prospects I have yet encountered.

Sincerely yours,

Philip Handler.

[From the Social Science Research Council, March 1969]

ITEMS

SOCIAL SCIENCE AND CONTEMPORARY SOCIAL PROBLEMS

(BY HENRY W. RIECKEN)

The social sciences, like the physical or biological sciences, are intellectual subjects, directed primarily toward understanding, rather than action. It would of course be a curious kind of "understanding" that had no implications for action, and this is perhaps especially true for the social sciences. Nevertheless, there is a difference between enlarging one's understanding of human behavior and society on the one hand and trying to solve a social problem on the other. The social sciences are distinct from social problem solving, but each can contribute to the other.

During the last few years there has been a significant change in popular attitudes and expectations in the United States regarding social change and social problems. A renewed determination to ameliorate certain longstanding, as well as recently developed, ills of the society has arisen along with a sense of power and confidence in its ability to do so.

In looking for ways in which to implement this desire for self-control, for directed rather than accidental improvement, a good many leaders of society have begun to turn, increasingly expectant, to the social sciences. Some have asked what the social sciences can contribute to the venture. Others have assumed that these sciences have a gread deal to contribute to a better society

and that they need only to be force-fed (the recommended diet varies from prescriber to prescriber) in order to grow faster and to make their contribution larger.

The social sciences do have a contribution to make to social practice but not so large a contribution as they will make if helped to develop properly. At this point in history, the magnitude of major social problems exceeds the capacity of social scientists to solve them.

Such expectations have been entertained before. In the latter part of the nineteenth century and the first decade or so of the twentieth, social scientists of the day offered advice to the progressive political and social movements of the times. As David Truman has pointed out, these political scientists and sociologists operated not only from a weak position in the political structure, but also with an almost total lack of theoretical sophistication, quite nonrigorous methods, and few facts about the systems on which they were advising.[1] They were intellectually premature and too ready to claim relevance. Their efforts fell far short of expectations, both their own and expectations of those who, from outside the disciplines, had called upon them.

Social scientists had another try during the early years of the New Deal when economists especially, but sociologists and political scientists too, were invited into government and other institutions to develop programs, plans, and social devices for dealing with the Great Depression. The novel thinking of agricultural economists and the resultant development of institutions for what was then known as "farm relief" were considerably more successful than the efforts of the social reformers of the early 1900's had been.

One reason for the relatively greater success of the applied economics of the New Deal was that there had been developing in the United States a considerable sophistication in economics as a discipline, together with a good empirical base of data that had been accumulated over the prior decades. In comparison with today's data base, that of the 1930's was poor and small; but it was a vast improvement over the virtual data vaccum of 1900. Another reason for the relative success was probably the degree of desperation that gripped the country and led to a willingness to try the somewhat radical measures that were proposed by economists; partly because people were willing to try the measures, they were successful.

Still another opportunity for the social sciences came during World War II when psychologists and anthropologists especially made significant contributions to the prosecution of the war and the government of occupied territories.

Social scientists are currently being offered a fourth opportunity to display what they have to offer toward the solution of what is now a fairly well-standardized, if incomplete, list of problems: poverty, racial segregation and discrimination, urban decay and the strangulation of transportation, human and mechanical pollution of the environment, and a perceived increase in the incidence of crimes of violence. Will social scientists succeed better this time in living up to the expectations that face them? What can and should be done to make possible greater success?

There are several purely scientific difficulties in applying social science successfully to the solution of social problems. Limitations of space prevent their adequate discussion here.[2] Their importance is such that they must at least be mentioned, however, and they require persistent scientific effort in order to improve the capacity of the social science disciplines to cope with social problems. There are three major scientific issues: socalled "Hawthorne effects" or changes in behavior which result from the fact that individuals are subjects in an experimental study; the inadequacies of existing data about social problems and individual behavior and the defects of indirect data; and finally the manipulability of social factors that are variables in social scientific analyses of problems. These are difficult scientific problems but not impossible of solution. Furthermore, much headway can be made in applying social science without fully solving them.

Over the decades in the social sciences the tendency has been to develop internal concerns, to define their own problems and not to accept, as their subject matter, the social problems of the contemporary and surrounding society. This tendency is attributable to forces intrinsic to the disciplines themselves, especially to conceptual redefinition of problems and to methodological or technical developments. A social scientist who undertakes to work on a practical

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[1] David B. Truman, "The Social Sciences and Public Policy: Maturity Brings Problems of Relevance and Training," *Science*, 160 : 508–512. May 3, 1968.

[2] These issues are taken up in the longer article in *Social Science Information* cited above.

problem, not as a wise man or a clever consultant, but as a scientist, quickly finds that the popular, or common-sense statement of the problem is either incomplete or misleading; that "the" problem is really many problems, only some of which fall within the disciplinary or scientific scope; and that there are severe inadequacies in the methodological or technical equipment that he has for dealing with "the" practical problem. Sometimes the scientist examines the "real world" because some part of it has solved a problem and the scientist wants to know how the solution works. After he understands how it works he can sometimes improve upon the solution, but the basic movement of his thought is always away from the practical and toward abstract knowledge.

The social scientist gets driven back to more fundamental questions that bear less and less resemblance to the practical problem until they appear to be irrelevant; furthermore, some of the more fundamental questions raised in this way take on a life of their own and become genuinely dissociated from practical problems. They form, instead, the central conceptual or methodological core of the science as such. Thus, over a period of time, a social science can grow more abstract and become increasingly concerned with questions that confront it as an intellectual enterprise per se, and that require solutions whether or not they bear upon the social problems of the day.

If these intrinsic intellectual forces were the only ones at work, a discipline would gradually lose all relevance. However, exogenous factors also have some influence. *For example, some people become social scientists who have a genuine interest in solving social problems and retain it despite the professionalizing experience of graduate study.* Market forces are also effective, especially grants from both private foundations and government agencies to support applied social research. The opportunity for a career in an applied field of social science is a market factor of importance. The very existence of professional economic consulting firms as private, nonacademic enterprises holds out the possibility of a career outside the academic world, and may tempt a young man who finds practical affairs more challenging than the intellectual world. The development of clinical psychology was greatly aided by the demands of the Veterans Administration directly after World War II for diagnostic and therapeutic help at its hospitals and clinics.

Another factor of importance is prestige. The social sciences are primarily *academic* enterprises, more so than either the biological or physical sciences and the acedemic portion of the discipline is not only overwhelmingly larger than other sectors but also overpoweringly more prestigious. The physical and the biological sciences, on the other hand, have substantial nonacademic sectors that are intellectually and scientifically influential, as well as of great and evident practical importance.

The prestige which most social scientists attach to academic social science may or many not be justified but it is a fact. The low status of applied work is probably undeserved, but it too is a fact and one that many discourage some first-rate scholars who are status conscious from entering early upon a career in applied social scence. The origins of this low status lie partly in the earlier relative failures of social scientists to deal adequately and successfully with social problems.

Even where applied social research has developed and has attracted competent people, it still has been applied research rather than what is called "development" (in the Research and Development sense) or "engineering." Most applied social research has been concentrated on the analysis of situations explaining or accounting for a given state of affairs; or the measurement of outcomes—and the degree of success of some action in reaching a stated objective. There has been less attention to preparing new means for taking action or recommending how a user should proceed in order to achieve success.

The production of recommendation for action goes beyond research and indeed beyond science, in what is properly termed "development" rather than "research," or "engineering" rather than "science." The distinction is more than berbal—it is a whole complex: a state of mind, institutional auspices, cross-disciplinary relations, communication with nonscientists, and employment of non-scienfic resources and nonscientific skills.

"Development" or "engineering" calls primarily for an inventive and constructive attitude, more than an analytic and differentiating one. The scientist is usually trying to unscramble a given complex situation to see how its components work. An engineer is usually trying to put together a device or a process to achieve a given purpose. The scientific process is analytic; the engineeering process is synthetic. The scientist's creativity is conceptual, in producing imaginative

new principles or connections between concepts. An engineer's creatively is in tangible inventions of things or processes that have a causative or productive relationship to a desired end.

Except in very limited and spotty areas, social development or social engineering does not exist. Examples of social engineering can be found in economics in the development of fiscal and monetary policies, and in psychology in new forms of psychotherapy (especially behavior therapy), programmed instruction, human relations training, the training of managers, and the social organization of production units in firms.

Organizational influences

The development of an applied social science or a social engineering may proceed faster through professional schools (especially business and medicine) than through disciplinary departments in universities.

The academically based research and teaching unit in the social sciences is affected by forces that hinder this sort of development. Some are organizational, some scientific; some derive from the institutional arrangements for the conduct of research in the social sciences. Most research is done in academic settings by part-time or short-term workers, i.e., by professors and graduate students. The former have teaching and administrative responsibilities that take up part of their time, the latter have a primary short-term interest in completing a dissertation and getting on in the world. The former work part time on a research problem, the latter leave it for other places or other problems after a relatively short time. Thus, many social science research problems are "thesis-sized" because they are selected for that reason. This tendency is abetted by the current system of project grants which tends to emphasize short-term investigation of discrete problems rather than long-term, exploratory and persistent pursuit of a problem, a phenomenon, a method. The absence of a tradition of long-term research careers on a full-time basis, the inflexibility of space that makes it hard to expand and contract the size of a long-term project as such changes become necessary, the varying requirements for skilled labor in interviewing and data processing (currently eased by computer applications), all contribute to sporadic interest, easy discouragement, and lack of persistence.

On the other hand, the real basic advances in social science seem more likely to occur in settings—such as disciplinary departments—that are relatively free of the pressures to devise immediate solutions, to work with client systems, and to attend to the range of extra-scientific considerations that are involved in solving social problems. A convincing argument can be made that the most pressing needs of social science are methodological and that the greatest opportunities for strengthening the social sciences lie in improving methods of research and developing more powerful theories. Indeed, a considerable amount of the advance in social science that has taken place in the last few decades has come about through basic research of this sort, conducted in disciplinary departments.

Thus conventional disciplinary departments and institutes that are genuinely embedded in universities can be counted on to provide the social scientific underpinning for solving social problems, but should not be counted on for the actual problem-oriented work itself. The latter task should be the responsibility of institutions that have less formidable intellectual responsibilities, and are free of the primary educational obligation. Furthermore, applied social research institutions ought to have some closer firsthand contact with social problems and the agencies that can take effective action on the problems.

Requirements for social science contributions to social problems

Where then should the responsibility for social science contributions to the solution of social problems be located? The phrasing of the question suggests part of the answer for, in the first place, a social problem rarely bears a one-to-one correspondence to social science, and almost never bears such a correspondence to any single social science discipline. All social problems are interdisciplinary in the sense that they require, for adequate solution, the efforts of more than one kind of scientist and usually of more than just scientists or engineers. Hence, the first requirement of an applied social research agency is that its professional personnel be drawn from a variety of disciplines (both within and outside the social sciences).

A second requirement, much harder to achieve, is that the assembled members of these disciplines be able to work together productively and effectively. This requirement demands first-rate scholars, not only curious about the problem at hand but also inquisitive about each other's fields and capable of learning from

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each other. Willingness to listen and curiosity are more important than anything else, since transfer of training among social scientists is entirely possible, and it may even help in the solution of, say, a psychological problem if an anthropologist without any particular training in psychology gets to thinking about it.

A third requirement is that the team have full opportunity of perform its functions of engineering and development. This requires certain kinds of facilities: buildings and computers—especially adequate "soft-ware" to go with the computing machinery and all the programming and other technical help that can be provided. One of the most useful techniques in social engineering is the simulation of the social processes that are believed to underlie the social problem. In many cases these simulations will have to substitute for experimentation because of the size or other intractable features of the problem.

A fourth requirement is long-term funding commensurate with the size of the social problem. It is a commonplace of American politics that social problems must be solved quickly. We are adjured to waste no more time in eliminating segregation, discrimination, poverty, crime, and unemployment. But while sense of crisis may impel movement, a lot of it is waste motion. We are too impetuous and not persistent enough in trying to solve social problems. Problems need sustained study, trials of many different kinds of solution rather than one-shot panaceas arranged overnight by agencies that are funded on an annual basis and publicly criticized for lack of instant success.

Problems in utilization of social science

One of the most interesting points about social science contributions to the solution of social problems is that the process of introducing the changes necessary to solve the problem is in itself a problem in social science. Before introducing changes into a quasi-stationary situation, the decision maker must consider a number of factors that affect the chances of success. First, he must consider the acceptability of his proposals to all the people involved in the situation; and the harm, damage, or deprivation that some of them may experience. Next, he must assess the effectiveness of the methods he expects to use to attract the attention and arouse willingness to explore, and the capacity he has to teach people new ways of hehaving. Finally, he must try to adjust the incentive and inhibitory factors in the situation so as to stabilize the new equilibrium and maintain the change he aims to bring about. Almost all of these problems exist in one form or another in utilization of the products of biological and physical sciences, too. But these sciences have not only an engineering or developmental branch that plus their ideas into usable form, but also a marketing mechanism—a set of activities and relationship that handles these problems or is so constituted that it can afford to ignore some of them.

On the whole, the marketing mechanisms for social inventions and devices do not parallel those for physical and biological technology. There are at least three reasons for this. In the first place, until recently, there have been few social inventions or devices that could not be marketed or disseminated either through existing political mechanisms in the public sector, or through publication, or through the establishment of a professional group such as clinical psychologists. It may be that marketing mechanisms will spring up in response to the appearance of new items to be marketed. For example, there are profit-making companies which now seem to be interested in developing and selling, as well as installing, new curricular materials and instructional procedures in the schools: and industrial firms have contracted to operate schemes for the alleviation of poverty—usually through retaining of the unskilled or underskilled. This trend has yet to be evaluated, but it could alter profoundly the nature of the process of social change. Secondly, there is difficulty in protecting property rights in intangible social technology. If the product is an idea, an attitude, a routine, it is hard to copyright and generally impossible to patent. The absence of protection of exclusive rights makes the prospect of investing in a marketing organization less attractive to an entrepreneur. Thirdly, much of the technological product of the social sciences has to do with the public rather than with the private sector of the economy, and is valuable for its distributive effect on the total society rather than for its enhancement of the quality of life of one individual at a time. Add to this the fact that a good many social inventions cannot be assigned a unit value, and one can see that the marketing mechanism must be the state in some form, rather than private enterprise.

Public policy issues in the application of social science

Some questions of public policy are raised by research and development activities in the social sciences. For example, what should be the public policy toward deliberate social experimentation, especially toward concealed experiments, in which the subjects are not aware that they are involved in an experiment? There are scientific reasons for concealment but the public policy problem is whether the probable gains from conducting such an experiment outweigh the ethical undesirability of acting in a less than open fashion. There is something repugnant about concealment of purpose, even when the motives for it are disinterested and no one is harmed. There is something upsetting about discovering that what one thought was a real and natural flow of events was instead a carefully contrived sequence of moves deliberately planned to accomplish a preconceived purpose.

The benefits to the general public welfare have to be balanced against these possible disadvantages. If experimental purpose must be concealed in order to obtain valid knowledge that will lead to improved social policies at a relatively low cost, not only in money but in mistakes and discomforts visited upon citizens, then the undesirable features of a concealed experiment may be outweighed features of a concealed experiment may be outweighed by its advantages. The judgment cannot be made *a priori* for all cases; it must depend in each instance on the estimated costs and the anticipated benefits. Perhaps the more significant public policy question is: Who shall make the judgment?

On a more general level, one may raise questions in terms of a conflict between two values: the advancement of knowledge, and the personal integrity and convenience of the individual citizen. Nowhere does this conflict become more explicit than in questions concerning invasion of individual privacy, especially in regard to the collection of detailed data about individuals and their maintenance in files that are presumably to be used for research purposes.

The issues here turn around safeguards as to how the data will be used, and in how much detail the data will be kept. Briefly summarized, what has been proposed is that certain kinds of data which are now regularly collected by various agencies (central and local authorities and perhaps private agencies, too) but kept in separate files and published only in aggregated forms be made available for research purposes on a disaggregated basis. More specifically it is proposed that data about individuals such as employment, income, savings, or expenditures be collected and stored in such a way that it would be possible to match the information from these separate series, by individuals. The anonymity of the individual and the confidentiality of the information would presumably be maintained as they are now. The data system would be used for research purposes, not for administrative ones.

Whether the very existence of a national data system would tempt those with legitimate access to make illegitimate use of the data is a much more serious question, going well beyond the data system per se. The question really turns around one's estimate of the likelihood of "big brotherism"—of a controlling government and a controlled society, and of the role the social sciences might play in bringing about such a situation or maintaining it. As our society grows in density of population, in interdependence, in complexity and technological sophistication, the need for rational planning and for the thoughtful and foresighted management of our affairs grows apace. And so does the need for vigilance in the defense of individual liberty, since there is always, as there always has been, the tempting possibility for those in power to "simplify" their problems by wielding their power in ways that constrict freedom and constrain the less powerful.

There is no reason, however, to see the social sciences as more culpable or more threatening than other kinds of science and technological development. The power of the state is increased by the development of sophisticated weapons for its police, more efficient communication among them, and by devices that enable eaves-dropping at a distance and through a wall. There are dangers in pharmacological control of behavior. Individual freedom can be abridged by the architecture of our dwellings and the design of our transportation, as well as by the laws which govern minimum wages, welfare payments, and income tax exemptions.

In fact, the social sciences can help to make us aware of threats to our freedom while giving us greater power to control our own behavior in constructive ways, helping us to be more tolerant of diversity, to learn to live together in greater harmony, less violently and more satisfyingly. If we are to reap these benefits, however, we must work at understanding ourselves and our society, at perfecting a social science that is capable of meeting the challenges of our future.

Senator KENNEDY. Senator Prouty.

Senator PROUTY. I have no questions.

Senator KENNEDY. I want to thank you very much, Doctor. I hope you will remain here as we continue with Dr. Haworth's testimony. I am sure there will be some areas on which we might come back to you for guidance.

I want to extend a special word of greeting to you, Dr. Haworth. I notice that you announced your resignation effective June 30. All of us who have reviewed your career know how much you have helped to shape our scientific research and education, and in what high esteem your work is held by scientists in America and abroad. Those of us in the Congress who have had the opportunity to come in contact with you will miss you. We appreciate very much your presence here today, and except to continue to call on you for guidance in the future.

I know you have provided a very extensive and challenging statement, which we will make a part of the record. If you would be kind enough to highlight it for us, I think this would be the best way to proceed, if that is agreeable with you.

STATEMENT OF DR. LELAND J. HAWORTH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. HAWORTH. Thank you very much. Mr. Chairman, both for the opportunity to appear before you and for your kind though largely undeserved words.

I echo your sentiments in the statement that you made at the beginning of this hearing as to the importance of these hearings. I think that the fact that the Foundation is for the first time going through the process of presenting these programs to two committees of the Congress is a very important step in its own right. I believe it is particularly timely for many of the reasons that have been discussed both in your statement and in Dr. Handler's testimony and the discussion that went along with it is timely because of the problems the Nation faces. It is timely because of the fact that there are the financial exigencies of which Dr. Handler spoke, and for many other reasons.

I do plan and had planned to do exactly what you say, Mr. Chairman. I think in a couple of instances, I will actually read the words of the statement, but otherwise, I will simply try to highlight it.

Senator KENNEDY. Fine.

Dr. HAWORTH. The first several pages of the statement relate to general matters that have already been covered, either by members of the committee or by Dr. Handler—such things as the flourishing state of American science, the fact that, however, one does now have to take pause because financial exigencies have forced us to level off, the past exponential rise in financial support, and also, something about the special role of the Foundation and its mandate to be responsible for the general state of American science, both by supporting research to advance the frontiers of human knowledge about the world in which we live, and also by building up of future potential for science through the training of new scientists and through the strengthening of the institutions in which these scientists work.

The Foundation particularly, of course, as Dr. Handler said, devotes its attention to the academic institutions because by so doing,

one can pursue these two objectives together, particularly because research conducted in universities, is itself as Dr. Handler said, part of the teaching processes at the upper levels of education.

The Foundation has endeavored to pursue this mandate, this general broad responsibility, with fairly modest resources. It has never provided more than one-eighth of the total Federal support of basic research and about one-sixth of the total Federal support of research in academic institutions, when one takes account of both basic and applied research.

We are, however, in addition, now faced with an especially stringent situation because of the leveling off of financial support, not only in the Foundation, which has actually suffered a sharp drop in its appropriation this year, but also the leveling off in other mission-oriented agencies that have supported this type of research in the universities because the knowledge, even very basic knowledge, developed in many of the fields will have ultimate utility for their missions.

These concerns are of two kinds: One is due to the fact that financial support has leveled off at a time when the education enterprise, and I particularly refer to the graduate education enterprise, continues to grow, when there are more and more, better and better students. There has been a doubling of graduate population in the last 10 or 12 years and it is anticipated there will be another doubling in the next 10 or 12 years. Along with this, of course, is the fact that costs for a given type of activity constantly increase, both because of the general inflation of, say, 3 percent or so, and because the complexity of science is ever increasing. To support a given science requires more complicated and costly equipment and more technical assistants, and so on.

For this reason, it is actually true, I believe, that the total level of research activity supported by the Federal Government in the universities is actually less than it was 2 or 3 years ago. We view this with concern, not only because it slows down to some extent the advancement of knowledge, but, more importantly, because it affects the opportunities for the training and education of future students.

You have already alluded in the discussion with respect to teaching that the universities do not have enough faculty. There are still not enough advanced students being trained. The junior colleges are, in large measure, having to man themselves by taking the best of secondary schoolteachers, and so on. So this general problem, of the support of the graduate enterprise, if you want to call it that, in the sciences, is of concern to us.

Unfortunately, as the other agencies have leveled off, we have not been able to step into the breach because our own financial resources have not increased. In fact, as I mentioned, they have actually decreased a little.

If we can take account of the increasing unit costs, the Foundation's total support, total appropriations, are not appreciably more than they were some 6 or 7 years ago in constant science dollars.

The second concern arises from the fact that the leveling of support by the mission-oriented agencies has brought about shifts in emphasis of the work supported by those agencies. This is a matter that was discussed at some length in the hearings before Mr. Daddario, so I shall not go into it so very much although there are, beginning on page 5 of my testimony, several pages relating to some specifics.

For example, the Defense Department has made policy decisions—which they might have made in any case, but perhaps not quite so quickly—to withdraw from certain fields of very basic science, such as astronomy and high energy and nuclear physics. I have no quarrel with that decision. They feel that other branches of science are more important to their mission and they are, of course, the best judges of that. But it has meant that the Foundation and to some extent, other agencies have had to attempt to redress imbalances that are brought about by this at a time when our own resources are not increasing.

A couple of examples are the observatory in Puerto Rico, known as the Arecibo Observatory, which was financed originally by the Advanced Research Projects Agency or ARPA, of the DOD, to conduct ionospheric studies. This is operated by Cornell University. It was also recognized that this would be a very fine radio telescope and the Cornell astronomers, with others joining in from other institutions, have actually turned it into one of the very best radio telescopes in the world. As time has gone on, the needs of the Defense Department for aeronomy research have dropped off somewhat as they have obtained the knowledge that they have needed, so the emphasis on radio and radar astronomy has gone up. This happens at a time when DOD has decided to withdraw or largely withdraw from this field. As a consequence, we have worked out an agreement with the Defense Department, partaken in by the Office of Science and Technology, that we would gradually take over the support of this telescope. This year, we funded, I believe about one-third of the total operating costs. Next year, we expect to fund about two-thirds, and at that time, in October, to take contractual responsibility for the telescope, and continue to operate it under contract with Cornell, but with the situation reversed in that, ARPA will now transfer funds to us rather than vice versa.

There are other examples. In the field of high energy physics, we have in recent years taken over the responsibility for several of the most competent distinguished groups in the universities in this field. Many of these groups were supported by ONR, which stepped into the breach way back in 1946 and first began to support this sort of research in universities, and, of course, initially supporting the very best groups. They have dropped off in the level of their support. The situation is that if we or someone did not pick up the program, some of the very best groups in the country would not be supported.

This again has been a plan, an internal process undertaken by the Department of Defense, the National Science Foundation, and the Office of Science and Technology. Some examples of groups whose support we have gradually assumed in the last couple of years are: groups at Columbia University, at the University of Chicago, California Institute of Technology, and we are just in the process of starting to support a project at Stanford where the principal man is Professor Hofstadler, who has won the Nobel Prize for his work using the linear accelerator. It is an especially promising endeavor, not only because of the very fine research that they do, but also because they have developed techniques by which very low temperature technology can be applied to accelerators, making possible much more powerful, higher current accelerators because of the fact that the resistance of the metal cavities can be made to disappear at very low temperatures and there is very little energy lost in the accelerator itself.

That takes me, Mr. Chairman, to my prepared statement. I have here a brief section on how we approached the question of resource allocation. I believe it says essentially everything that I would try to say. It is a thing that is not easy to highlight. I think I will simply call your attention to it and not try to speak to it except to say that this is obviously, as you pointed out in your own satement, a very complicated matter. It is a matter of where should science be supported, what kinds of science should be supported, taking into account the needs of society for knowledge in given fields, taking into account the relative opportunities for advancement in various fields of science. However great the need may be, there is no use in trying to do crash programs in fields in which one has no promising leads for making advances, and so forth.

There is also the question of the relative support of research versus the support of education in the more formalistic sense, versus science information and so forth and so forth.

I will call attention to the last paragraph on page 15 of that section, which points out how many individuals and groups of individuals partake in this decisionmaking process. There are, of course, the executive offices, the Bureau of the Budget, the Office of Science and Technology, the indirect help we get from the President's Science Advisory Committee. There are many interagency committees that we participate in and so on. We, of course, make great use of the National Academy of Sciences, which has already been mentioned. And we have our own advisory committees, and lastly and most importantly, the National Science Board itself. So that this whole question of resource allocation is given a great deal of very detailed attention.

But we cannot pretend that there is any preciseness about the decisions that we make. Many of the factors are very intangible. There is no such thing as cost-benefit analysis in research, because we do not know what the results of the research are going to be, we cannot see what the usefulness of those results is going to be, and so on.

Let me turn now to the funding request itself on page 16, of which you are undoubtedly already completely familiar with the general outlines. We have requested authorization from this committee for an appropriation of $487 million and for $3 million equivalent in excess foreign currency. In our total appropriation request, there is also included $10 million which would come under already authorized legislation.

Senator KENNEDY. In our review of many of these programs, it is necessary to establish some kind of criteria to measure the programs' effectiveness and the level of resources which is appropriate. With regard to the defense budget, however, there are those who say that $80 billion will provide national security, but that $75 billion will prove inadequate. Just prior to page 16, you say many factors entered the deliberations leading to your funding request. Can you give us any assistance in justifying to the members of the full committee and to the Senate why this figure can do the job, whereas a lesser figure cannot?

Dr. HAWORTH. Well, Mr. Chairman, as I said, I cannot claim that there is any preciseness, any real preciseness about this. But there are a number of guiding factors. One of the most important ones to the Foundation is the question of the strength and vitality of the uni-

versities in their scientific endeavors. One of the factors, on which there were some numerical calculations, was the amount would be necessary in terms of additions to the Science Foundation's budget to assure that research activities in the universities, would not diminish compared to the 1968 level, assuming that increases in other agencies would just be sufficient to overcome the rising costs, without attempting to cover expansion in people. This was factored into the calculations. Within the total sum allocated to us we were not quite able to meet that, but, you will note the table on page 17–A, that our request would increase research support by a total of $55 million. Most of that is because of this need to try to keep up with the increasing needs of the universities. Some of it, of course, also results from particular opportunities in science, but that consideration affects how we distribute the funds more than it does the total funds.

Another consideration, and this is not part of the authorization that this committee is asked to make, since it has already been authorized, is that we are very impressed by the national sea grant program and its successes and we have asked for a 67-percent increase in our funding for that.

A third item in which we have requested a significant increase is the support of institutions. On page 17–A, it is the line called "Institutional Support for Science." Now, as you will note, this is an item that suffered very severely this year as a result of appropriations reductions. In fact, it is less than half the fiscal year 1968 level. We are trying to get this group of programs back to somewhere near the 1968 level. Those programs are of several kinds. They support the construction of new laboratories, a very modest amount. They include a formula grant which is given to the institutions on the basis of a tapered formula based on research support which gives them flexible funds with which they can fill in the gaps, so to speak, between the project grants.

It also includes three programs directed at trying to assist the institutions to improve the quality of their science research and education, particularly those that are strong but not of the very best. We have two programs at the graduate level, and one predominantly for the 4-year colleges.

The rest of the budget is essentially keeping the status quo, or at least the status quo of last year. For the computing activities, we had $22 million last year, we are requesting $22 million for next year. This is very modest in view of the fact that the need for computers, of course is ballooning in a tremendous way as Dr. Handler indicated.

So far I have talked more about the types of support rather than the breakdown into disciplines. Again in research; for example, the request would at least maintain the status quo in all disciplines, but we have put somewhat larger relative emphasis in engineering and in social sciences as a result, in large part, of the changes introduced by the Congress in our basic act authorizing us to support applied research, a lot of which, of course, will be in engineering and in the social sciences, and also because of the expressed interest in and our own feelings about the need for greater strength in the social sciences.

We have also introduced the item that Dr. Handler spoke of—interdisciplinary research. I would like to speak to this a moment. There are a few pages in my written document, but I think I will not try to

read them in light of the discussion that has already been held, but will merely ad lib a few of my own feelings about it.

Our support of research has been almost entirely broken into the various disciplines—physics, chemistry, biology, and so on. Now, there was always inherent in this, of course, the opportunity for us to use part of our social science funds, part of our engineering funds, part of our biology funds, say, to finance some multidisciplinary or interdisciplinary activity. But unless there is a focal point, this does not really happen. In the first place, people who have an interest in attacking problems in a multiple way have no assurance or no place to go, no particular staff to go to make proposals for this type of thing.

So I think even if it were not true, as it is, that there is a need for interdisciplinary research from the standpoint of attacking our social problems, it still would be true that there does need to be a focal point for this type of activity.

Now, this is greatly enhanced by our feelings about the need for multiple attacks on these many problems and our feeling with respect to the Foundation as distinguished from other agencies is twofold. We think of this as complementing or supplementing the activities of some of the agencies such as Housing and Urban Development, Transportation, and so on, but in two particular ways. First, the Science Foundation—because of its history, its method of operation, and so on—is much more familiar with the academic community, its potential, its interests, and so forth than are other agencies. Hence we believe that we are in a very good position to exploit—and I say that in the nice sense of the word, not the bad sense—to exploit the latent capabilities in the universities for groups getting together and attacking the problems—not necessarily trying to solve specific problems, but to get the underlying coherent information that will enable those who have to deal on a day-to-day basis with the problems to really attack and solve them.

Now, it is not expected that this will mean that the particular people spend more time in the research, it is that they will do different research. And they will do research in concert instead of in isolated cubbyholes and will try to have interplay in which the work of one kind of man supplements and interweaves with the work of other kinds of men.

A second point is that many of these variegated areas that are not being properly pursued are, although of interest to many agencies, not necessarily of acute interest to any one agency. We hope that in many instances the program will develop information that will be useful to several agencies, in other words—the whole will be greater than the sum of the parts.

Senator KENNEDY. Doctor, how do these sorts of reports and studies differ from the kinds of task force reports on domestic needs and problems that have been prepared for President Johnson and President Kennedy, and to some extent for President Nixon? I realize it is extremely difficult to pin this sort of thing down, but it still seems to me to be somewhat unclear. I am trying to get a better feel for the focus of this interdisciplinary research program, and how it is going to function in practice.

Dr. HAWORTH. Let me first answer your question and then comment on your comment, if I may.

Senator KENNEDY. Yes.

Dr. HAWORTH. The way in which this will differ from the studies that you have described is that those studies of necessity are simply compilations and analyses of existing knowledge, as might be done in any single field, as well as across many fields. What we are intending here is that there should be actual research by these combined groups that will extend the knowledge, not merely analyze and compile and annotate knowledge that already exists.

Senator KENNEDY. Would that be done through research and pilot projects?

Dr. HAWORTH. Yes.

Senator KENNEDY. Would you also be interested in altering university curriculum in connection with this program?

Dr. HAWORTH. Undoubtedly, some of that will be done. A very important thing, I think, and I should have alluded to it earlier, is that we hope that by having these concerted groups interested in particular problems that are of a complex nature, there will be students who become interested in this type of thing—as gradaute students, especially—and that as time goes on there will begin to be experienced, well trained, wise people who have a background of this sort and not simply have entirely, say, a physics training and then try to use it in analyzing this or analyzing that, but will become specialized generalists, if I can use that term, that is, people who are interested in and knowledgeable about the many facets of these problems. To what extent will this result in curriculum in the sense of something that somebody lectures about is very hard to foresee.

Now, as to your comment on vagueness, it is admittedly vague. It is frankly an experiment, as I say, in this text. But, as Dr. Handler has pointed out, there are many groups in the universities who have ideas about attacking many problems, such as communication between various elements of society, questions of the interaction between the capability of doing something and the will to do it, as you expressed it an hour or so ago and any number of other complex subjects. We just do not know, until we have had more dialog with a number of these groups, what will be the most promising of these activities to support. We do not intend to use a shotgun approach and just support a bit here and a bit there in this program, but rather to concentrate on a few things which we will identify as a result of discussions with our own advisers, with the people who would coalesce to do this sort of work, and so on. We have been urged very strongly by some of our advisory committees to have such a program. Our engineering advisory committee, for example, made a formal recommendation to me that we undertake this type of program.

Following pages 17 and 17–A, where the tables show the breakdown of how we propose to use the funds, if finally authorized and appropriated, are discussions and descriptions of various facets of the program. We have already been talking about one, the interdisciplinary research.

I have already mentioned that we expect to increase some things more than others, the support of engineering and the social sciences, the research support, for example.

I have already mentioned that we would like to get the institutional programs back to somewhere near where they were a year ago. I have

already mentioned the see grant program. I have already mentioned the computers.

I would like then to point out one particular thing that is of great concern to us that is not shown in the tables and not in that detail. That is the very great need for refurbishing and adding to our stock of large equipment and facilities. During the past several years, as we have had financial stringencies, we and other agencies have tended, and I think correctly, to try to maintain our on-going programs, to keep people working, to let them improve themselves and fellow their careers and so forth, at the expense of giving them increased opportunities with respect to the types of things that they do. And as a result, there has been a great dimunition in the support for equipment and facilities, scientific facilities, and also for general laboratory facilities.

For example, if I remember rightly, the specialized facilities and equipment item, as we call it, was a $27 million item in fiscal year 1965. It has dropped year by year until this year it is only $5 million. This is just a pittance in terms of the total needs. So part of the increase over this year that we are requesting for research support is to increase facilities and equipment by $10 million.

Now, this is mostly for fairly modest equipment, chemical instruments, things of that sort. But part of it is to provide two fairly major items. One is to improve the radio telescope at Arecibo. This is the same installation that I spoke of earlier, but I am now speaking of capital improvement as distinguished from supporting the on-going research. We would like to spend about $3.3 million to provide an improved surface for the reflector of that telescope so it can be used at much shorter wave lengths, much higher frequencies, and be a much more effective instrument for radio astronomy. If that were done, and if later, a new radar transmitter were placed there, this can also become a very, very powerful instrument for planetary radar astronomy as well as for radio astronomy.

The other major item is an oceanographic research vessel. The fleet of about 30 oceanographic vessels that we support is mostly very old. Many ships are 25 years old or more. They are wearing out so that quite apart from the need for a larger fleet, there need to be replacements. And we are proposing that there be one such replacement next year. We are expecting to provide one from current funds this year. Next year's vessel, would cost $2 million.

This would be a new type of research vessel. It would be an adaptation of the type of supply boats that the oil companies and other companies use. The laboratories would be on the deck and would be fully equipped laboratories that could be simply removed by crane and replaced by other laboratories as the needs change and so on.

Those are some of the highlights of the program in which we have either requested appreciable increases compared to this year or, in some cases, where there was particular interest and discussion on the part of the House committee, which interest has been echoed by your own staffs.

So, unless there are questions about the program—may I call your attention to the fact that each one has a brief description in these last 30 pages or so—I would like then to turn to the very last and for a moment stop at page 48 and point out our planning and policy studies,

which relate very closely, of course, to the special mandate given to the Foundation, especially to the National Science Board, to take an active part in assembling data, in analyzing data, in making proposals that relate to the use of resources and to science policy, both Federal and national, and so on. There are outlined there some of the types of activities, some are external activities, others are carried out by our own staff.

I would like especially to mention that we have recently embarked on a very modest program of supporting studies at the State level as to how States can best utilize their scientific and technological resources. We have just a couple of grants for this type of thing. The grants were given not to the State itself but to a university—the University of Tennessee is an example—but in close cooperation with the State government. The government of Tennessee, for example, is very interested in this. The State has also provided some money. They are trying to analyze what are their needs, how can they best exploit their own scientific and technical talents, resources, opportunities, and so forth.

Senator PROUTY. Dr. Haworth, could I interrupt there? I am quite interested in the program. I think the House subcommittee increased your request of $270,000 by $150,000, is that right?

Dr. HAWORTH. That is right.

Senator PROUTY. I very much hope that that program can be expanded. I think it is very, very important.

Dr. HAWORTH. Thank you. In a similar way we have tried to exploit regional studies of the same nature, although that has been limited so far to supporting interstate conferences. We supported a conference, for example, at Louisville through the Southern Governors' conference.

Then finally, I would like to turn to page 51 and read the last couple of pages, because they sort of summarize my own thinking. I take entire personal responsibility for the views I will express.

In this highly condensed overview, I have tried to present a number of highlights of the Foundation program and the plans for the coming fiscal year. I have wanted to convey to you an impression of the exceedingly broad, complex, and varied nature of this program. The work of the Foundation, however, is the response to a need; it is not imposed upon the academic or scientific communities. This need is real and it is rapidly growing. During the past few years the Foundation, and indeed the Federal Government, has failed to keep pace with this need. The many reasons for budgetary caution today are well understood. But when this caution is focused on one of the great sources of American strength, namely, the university and the academic community, the implications for the future of the Nation are serious.

Within the next few years it will be necessary not only to increase the general level of support but to take steps to meet some specific needs which have been aggravated by the necessity of neglecting them to keep the general program going. In particular, I believe that greatly increased investments will have to be made to provide more equipment and especially to provide such very advanced specialized facilities as large radio telescopes and oceanographic research vessels.

Another rapidly growing need is for computers, both to replace older models with higher capacity ones developed in recent years and to make computer services more generally available. There is also a growing, almost crucial, shortage in universities with respect to general laboratory space, Federal funds for which have been held at a minimum in the past few years.

Over the longer range the outlook becomes even more difficult. Two estimates of the future assume special importance: It is projected that the number of the Nation's graduate students will double by 1980, reaching a total of about 1.3 million by that time. Of the order of one-third of these students are and will be enrolled in science and engineering.

Because of both the rising graduate population and the ever increasing unit costs of science, the anticipated annual cost of graduate education in the sciences is expected to quadruple during the same period. That is only a decade.

In spite of increased contributions to higher education, and especially graduate education, by philanthropic organizations, by industry, and by State and local governments, the rate of such increases cannot match this escalation of cost. All recent studies agree that a substantial share of the funding needed for this period of dynamic growth will necessarily be derived from the Federal Government. At the same time the Federal agencies that have constituted the major support of academic science and graduate education in the sciences will continue to experience changing priorities, the maturing and termination of specific programs, and uncertain appropriation patterns. Each of these factors can and does have unfortunate, although inadvertent, effects on the stability and effectiveness of the educational process, effects that are ultimately felt at all educational levels. If the Foundation is to be fully effective in its role of strengthening the scientific research potential of the Nation and mitigating these effects, I believe that, as additional resources are made available for academic science, a larger proportion than has been the case in the past should be assigned to the Foundation. This I believe would help provide a more stable base to the academic science enterprise—a base upon which other agencies could build in fostering research of particular concern to their own responsibilities.

In conclusion, I would like to say that we have done our best to propose a well-balanced program, one that is thought out as well as we are capable of doing it, seeking and using the best advice that is obtainable, and we welcome your review and consideration of the program.

Senator Pell (presiding pro tempore). Thank you. Not having been here for the whole of your testimony, I will defer to Senator Prouty for his questions.

(The prepared statement of Dr. Haworth follows:)

Prepared Statement of Dr. Leland J. Haworth, Director, National Science Foundation

Mr. Chairman and members of the committee, it is my special privilege to appear here today in support of the Administration budget request for the National Science Foundation for Fiscal Year 1970. Since these hearings mark the first time that the appropriation to the Foundation has been subject to an annual authorization, this occasion represents an important turning point in the development of the Foundation and in its capacity to serve the American people. The

beginning of a broadened and ever more constructive partnership between the Foundation and the Congress will certainly contribute to achieving the purposes for which the Foundation was originally established. We welcome, therefore, this opportunity to appear before you, to review the nature and objectives of our proposed program, and to discuss the outlook for the future and its significance, as we see it, to the well-being of American society.

Since the end of World War II science in the United States has flourished as never before in man's history anywhere. I believe that everyone is aware of the continuing contributions of science to the national security, to the public health, and to the dynamic growth of the economy as a whole. And I believe that we can take pride in the central role that has been played by the Federal Government in the support of research and development. Through this support, provided by many agencies, the great laboratories and research centers of the Nation—public and private, industrial, academic, and governmental—have been strengthened and enabled to build the resources that are available today for ever expanding opportunities for public service.

Unfortunately, we are now in a period in which significant changes have been and are taking place in the patterns of support and performance. In place of an average annual compound growth rate of 12 percent for scientific activities expenditures, which existed during the period 1953 through 1965, we have now essentially leveled off total expenditures in this sector. The impact of this leveling off has not been uniform and some programs and institutions have been severely affected; this impact is especially severe in the Nation's graduate universities, faced as they are with rapidly increasing student enrollments and the consequent need for larger faculties, and rapidly rising unit costs resulting both from general inflation and from the increasing complexity of science. This adverse impact is of especial concern to the National Science Foundation.

The National Science Foundation resulted from a concept, born before World War II had ended, that it would be desirable to have a Federal agency devoted to the support of science. From the early conceptual proposals, through the enabling legislation, the "National Science Foundation Act of 1950," to the recent revision of the Act sponsored in the Senate by this Committee, one clear mandate emerged and has remained unchanged, namely, the Foundation's responsibility to exercise a Federal leadership role in the development and maintenance of American science. Under this mandate, the overall nourishing of science by the Foundation has included the development of new knowledge, the development of the scientific and technical manpower required by a modern science-technology oriented society and the maintenance and development of institutions required for both of these functions. The programs evolved to accomplish these tasks have been designed primarily to further the growth and welfare of research conducted in the academic and academically oriented institutions and of science education at all levels.

That the universities of the National conduct the preponderance of all basic scientific research and that an even larger portion of the very best basic research scientists are found in them makes it inevitable that the research programs of the Foundation, responsive to its primary mission to advance scientific knowledge, should have been directed in major part to these institutions. There is, however, another very special reason for making this overwhelmingly the case. Basic research in the university is an integral part of the process and the environment of graduate education in the sciences. Thus support given to the pursuit of scientific knowledge and understanding through research in universities collaterally supports the education of graduate students, not only through research assistantship stipends for some but, much more generally, by underwriting the costs of the research that they pursue as part of the educational process. For these reasons, the Foundation directs more than four-fifths of its research support to academic institutions—a far larger fraction than does any other agency—as well as supporting and contributing to their general strength and development through institutional assistance. It is for these reasons that the Foundation plays a unique role in strengthening academic science and science education and thereby contributing to the Nation's scientific strength in both the present and the potential sense.

Throughout its history, the Foundation has endeavored to carry out its mission as best it could with only very modest resources. At no time has its budget been such that it provided more than about one-eighth of the total Federal support for basic research or about one-sixth of Federal funds for academic science. Consequently, although the Foundation has been a principal supporter of certain fields—e.g., pure mathematics, ground-based astronomy, systematic and environ-

mental biology—it has not been able to assume the across-the-board leading role in the support of all areas of science that was contemplated at the time of its inception.

The Foundation must, of course, be fully aware of and adapt itself to the changing patterns of support of science by other agencies. Recent trends, arising primarily from budgetary stringencies, have given cause for two types of concern in this regard.

The first relates to general levels of Federal support for graduate education. Fellowship support of graduate students has markedly declined. Even more important has been the leveling off of support of academic research. Just as does that of the Foundation, support of academic research by other agencies contributes to graduate education. Indeed, it is estimated that Federal research grants and contracts constitute approximately three-fourths of Federal and more than half of total support of graduate education in the sciences. Hence, in the present context, the growth of such education is vitally dependent on increasing Federal support of academic research. But there has been in this situation a potential for difficulties, arising from the fact that the research requirements of the various agencies pursuing specific missions do not necessarily coincide, either in quantity or in kind, with the needs of the universities for increasing support of graduate education to match the growing aspirations of the country's youth and the ever greater national need for highly trained scientists. Fortunately, until recently these circumstances did not give rise to serious difficulties, since the overall needs of the combined agencies did keep pace with the overall growth of graduate education, and the plurality of support plus the potentiality of internal adjustments by the Foundation, and to a lesser relative degrees by others, preserved a reasonable balance among the various disciplines.

With the advent of budget stringencies in recent years, however, serious problems have arisen. Because of these stringencies several agencies with important science programs have been forced not only to restrict their academic research support generally, but to confine it largely to those fields and problems that are closest to their established missions and short-term needs, with consequent serious impact on academic research. The result has been that, although the decision was made, as an expression of the public interest, to limit the Federal effort in research and development, not to reduce support of a major element of the educational process, the latter has occurred in consequence. I believe that, for this reason, a careful distinction should be made in budgeting and appropriating funds between those for research to be conducted in our colleges and universities and those for other research and development appropriately sponsored in Federal laboratories, industry, and not-for-profit organizations, important as that is. Support by the Federal Government of academic science, a matter that is inextricably involved in higher education, should be determined and awarded in its own right, not as an anonymous part of a much larger and often unrelated effort.

Unfortunately, because of inadequate growth—and this year an actual reduction—in its own resources, the Foundation, which has an inherent statutory responsibility to support graduate education in the sciences, has been unable to exert an effective countervailing force, one that could offset the effect of budgetary retrenchment. In fact, if total obligations by the Foundation are considered in terms of estimated "constant research dollars" computed on the basis of an assumed annual increase of 3 percent for general price inflation and 4 percent for increasing complexity of the research process in the sciences, its annual support has not changed substantially during the seven-year period since 1962, a period during which total graduate enrollments have increased from 422,000 to more than 750,000. In short, the Foundation has been progressively less able to discharge its responsibilities under its statutory mission in relation both to the magnitude of the evident need and to the opportunity afforded by the burgeoning state of science during the present decade. Consequently, the academic institutions are experiencing not only leveling off and in some instances actual reductions in overall Federal science support, without adequate regard to their institutional needs and stability, but also are experiencing changes in the funding levels of individual activities which have occurred on relatively short notice and with increasing frequency.

While it is too early to assess fully the adverse effects of these recent trends, it is clear that if the trends continue those effects will be severe. There is mounting concern that reductions in the national priority of science will inhibit institutional flexibility and planning capabilities; will restrain scientific investigations and militate against the undertaking of daring and often costly experiments

which can lead to breakthroughs in favor of safe, sure contributions; will lower the quality of graduate education; and will discourage students from seeking careers in science and technology.

The second concern of the Foundation that arises from the leveling of research support by other agencies relates to the need to continue the advance of basic knowledge in all fields of science. Except in a few instances, such as the National Sea Grant Program, the mission of the Foundation is not directed toward the achievement of specific, well-defined goals to which science and technology can contribute; it is concerned instead with the present and future strength of the whole spectrum of science in the United States. When, therefore, it has been determined by a Federal agency that the support of a particular field of science is no longer as relevant to its assigned mission as in the past, that work has reached a point where continued support would lead to diminishing returns in relation to the specific mission, or that a reassessment of priorities is required because of budgetary considerations, it becomes necessary for the Foundation to review the activity threatened with reduction or even termination, and to consider it, in competition with other activities, for inclusion and continued support within the total program of the Foundation. I should like to mention two current examples, both of which are reflected in the present budget request. They result from the decision of the Department of Defense to withdraw its support from research in astronomy, other than that conducted within its own laboratories, and from research in high energy and nuclear physics. There can be no criticism of the Department of Defense in arriving at these decisions. Yet they have come at a time when these fields are exceedingly vigorous, when the opportunities for important scientific accomplishment are increasing, and when the position of the United States in these fields, albeit strong, is by no means unique among the community of nations.

A specific example of the first is the observatory at Arecibo, Puerto Rico. Undertaken by the Advanced Research Projects Agency or ARPA of the Department of Defense primarily for ionospheric studies, and operated by Cornell University, this gigantic installation, with an antenna 1000 feet in diameter, has become one of the world's finest radio astronomy observatories, one that has, for example, contributed vitally to the recent exciting research on "pulsars." As the need of the Department of Defense for this facility diminishes, the Foundation proposes to exploit the opportunities for radio and radar astronomy at this location and to transform it into a National Research Center, available to scientists, graduate students, and faculty alike for research in radio astronomy. Toward this end we have partially supported the radio astronomy this year by transfer of funds to the Air Force, which has administered the contract for ARPA. Beginning in October, we plan to assume contractual responsibility and to provide complete support for the research in radio and radar astronomy; ARPA will continue to fund the ionospheric research by transfer of funds to the Foundation. A separate consideration is a proposed project to greatly improve the facility by providing a much higher precision surface for the 1000 foot reflector. This undertaking, which I will discuss later, would be proposed even though the Foundation were not assuming full operating responsibility.

Other specific examples concern the support of high energy or elementary particle physics. Shortly after the close of World War II comprehensive support of academic research in the general field of nuclear physics was undertaken by the newly formed Office of Naval Research or ONR. As a result of this developing program many of the most outstanding groups on nuclear physicists in the Nation worked under the sponsorship of ONR and, later, many of them moved on to elementary particle research as higher energy accelerators were developed. The withdrawal of this support by the Department of Defense in the absence of other sources of support would thus have had extremely serious consequences for the strength of these important branches of science in the United States; hence, by mutual agreement between the Department of Defense, the Office of Science and Technology and the Foundation, a planned program of transfer of sponsorship to the Foundation has been in progress. Some of the more recent transfers in these areas are a large nuclear physics project at the California Institute of Technology, important elementary particle projects at Columbia and the University of Chicago, and, only last month, a project at Stanford in which cryogenic or low temperature technology is being applied to make possible much improved particle accelerators.

I think it is important to emphasize that support of these projects is entirely consistent with the mission of the Foundation and with its policy of supporting work of outstanding merit and high scientific promise. All of them have competed successfully in an evaluation of quality and the Foundation is proud to include these projects in its program.

RESOURCE ALLOCATION

Implicit in the foregoing discussion is an exceedingly complex process of allocating the funds available to the Foundation. Quite apart from the obvious but understandable constraint of limited funding in the face of the increasing needs of the growing number of scientists, the preparation of a budget by the Foundation differs in a fundamental sense from that in many other agencies, where the process consists of establishing priorities among a group of more or less unrelated activities characteristic of programs heavily committed, for example, to the development and production of hardware. The problem of the Foundation is made especially acute by the fact that its role encompasses all aspects both of basic science and of the educational system that are associated with academic science. Its programs, therefore, include the maintenance of the quality and continuity of science itself through the support of worthy research and the protection of the academic environment of student and teacher within which the Nation's scientists and engineers have their origins; assistance in the provision of necessary science facilities and specialized equipment; the provision of major national centers of "big science" where research on the frontiers of science can be conducted, with participation by "visiting" students and teachers; the development of the quality and effectiveness of academic departments and entire institutions; the support of students; and the insurance that the fruits of science in the form of scientific and technical information will be available to those who will carry the work further. They also include support for the improvement of teaching methods through the expanded use of computers and other scientific devices and techniques, the development of curriculum and course materials at the elementary and secondary level, and the training of teachers.

All of these activities must be supported, in appropriate balance, with full regard for the specific needs to advance knowledge in individual scientific disciplines and for the continuity of the educational process itself. As already noted, the Foundation must take account of variations in the programs of both Federal and non-Federal agencies, variations that are occasioned both by national budgetary constraints and by the maturing and completion of specific programs and support in other agencies. And, as I also mentioned above, these services must be provided under the circumstance that the Foundation's financial contribution to the scientific enterprise of the Nation is small when compared to the total Federal or national commitment.

The way in which the Foundation arrives at its budget request is thus an involved matter. It is not amenable, I should add, to mechanistic models or mathematical procedures or to the planning and projection of isolated projects. It necessarily begins with regard for the continuity of programs that have been initiated, established, and developed to their present status, programs that have fully demonstrated their worth within the total pattern of academic science. Additions to and variations from this pattern of support are necessarily a matter of judgment, of examination of alternatives, of frank discussion, and of trial and error by many individuals during a lengthy period of planning and study, all subject to an assumed level of total available funding.

Many factors entered the deliberations, for example, that resulted in the funding to be requested for Support of Scientific Research, the largest item of the budget request. A quantitative factor that was initially considered was the estimated amount that such support by the Foundation would need to increase in order to maintain stability of academic research under the seemingly likely circumstance that the level of academic research activity supported by the combined budgets of all other Federal agencies would remain approximately constant. Other factors included the current needs of the individual sciences and the numbers and rates of increase of faculty and students in these different fields. Past and current experience of relative proposal pressure was taken into account as one measure of differential need. In addition, account was necessarily taken of previous commitments and the continuation of major research undertakings that has already been started.

Among the most important considerations are those relating to priorities among the various areas of science, taking account of both the needs for particular kinds of knowledge and the estimated promise that important progress can be made. These considerations result in shifting patterns of emphasis from time to time. For example, in recent years the Foundation has been giving increasing emphasis to the marine sciences, including but not confined to the National Sea Grant Program; to Ecology, especially through the International Biological Program; and to the Social Sciences. New knowledge in all of these fields will, in our opinion, lead to the eventual betterment of humankind.

The determination of the budget request, the tangible expression of resource allocation by the Foundation, is thus the result of a large number of individual, interrelated considerations, few if any of which could be fully satisfied. This process of determination is a continuing one—one that is assisted by studies by many groups within the Government—including the Bureau of the Budget, the President's Science Advisory Committee, the Office of Science and Technology and many Federal interagency committees which include members of the Foundation staff. External assistance comes from our own advisory committees and from studies conducted by the National Academy of Sciences. Of special importance is the overall review of the budget made by the National Science Board.

THE NATIONAL SCIENCE FOUNDATION FUNDING REQUEST

That part of the Foundation's budget request for Fiscal Year 1970, which is represented by the Authorization Bills under consideration by this Committee, includes $487.0 million of new obligational authority and $3.0 million of excess foreign currency. In addition, $10 million for the National Sea Grant Program, already authorized under Public Law 89–688, as amended, and $20.0 million of previously appropriated funds placed in reserve during prior years by the Bureau of the Budget and made available for the Fiscal Year 1970 program, would lead to a total of $520.0 million available for obligation by the Foundation were an Authorization Bill to be enacted at the proposed level and the requested total of $500 million in new funds appropriated. The following tabulation will serve to reconcile the authorization and appropriation requests for Fiscal Year 1970. The total of $520.0 million should be compared with the actual obligation of $465.0 million in 1967, $505.2 million in 1968 and an obligation availability of $435.0 million in 1969. Comparisons from 1968 on are made in the second tabulation which follows.

RECONCILIATION OF AUTHORIZATION AND APPROPRIATION REQUESTS FOR FISCAL YEAR 1970

[In millions of dollars]

	Authorization				
	To be authorized under Public Law 81–507, as amended	Authorized under Public Law 89–688, as amended	Appropriation requested	Available from reserve under Public Law 90–364	Total estimated obligations
Salaries and expenses appropriation:					
Support of scientific research	248.6		248.6	10	258.6
National sea-grant program		10	10.0		10.0
Computing activities in education and research	22.0		22.0		22.0
Institutional support for science	69.0		69.0	5	74.0
Science education support	112.5		112.5	5	117.5
Science information activities	13.0		13.0		13.0
International cooperative scientific activities	2.0		2.0		2.0
Planning and policy studies	2.9		2.9		2.9
Program development and management	17.0		17.0		17.0
Subtotal, salaries and expenses appropriation	487.0	10	497.0	20	517.0
To be authorized: Scientific activities (special foreign currency) appropriation	3.0		3.0		3.0
Total, NSF	490.0	10	500.0	20	520.0

SUMMARY OF NATIONAL SCIENCE FOUNDATION OBLIGATIONS, FISCAL YEARS 1968, 1969, 1970

[In millions of dollars]

	Actual fiscal year 1968	Estimate, fiscal year 1969	Estimate, fiscal year 1970
Support of scientific research	$236.5	$223	$258.6
National sea-grant program	5.0	6	10.0
Computing activities in education and research	22.0	17	22.0
Institutional support for science	83.2	41	74.0
Science education support	124.8	116	117.0
Science information activities	14.4	11	13.0
International cooperative scientific activities	1.4	2	2.0
Planning and policy studies	2.4	3	2.9
Program development and management	15.4	16	17.0
Subtotal, salaries	505.2	435	517.0
Scientific activities (special foreign currency appropriation)			3.0
Total	505.2	435	520.0

It should be emphasized that the breakdown of allocations shown in these tabulations is to a considerable extent arbitrary. I have already discussed the interaction between research and education, particularly at the graduate level. Furthermore, although the two largest budget categories are labeled Support of Scientific Research, and Support of Science Education, they by no means include all of the support for such activities. As you are well aware, the National Sea Grant Program specifically supports both research and formal education in the classroom sense. The same is true of the program in support of Computing Activities in Education and Research. The Institutional Development Programs assist universities and colleges to improve the quality of both their research and their science education. It should also be pointed out that the category identified as International Cooperative Scientific Activities includes only those programs where the international aspects are the primary consideration; in addition, many programs budgeted under Research, Education and Science Information significantly involve international activities in science.

THE FISCAL YEAR 1970 PROGRAM

Because of limitations on time I will only summarize briefly the proposed Fiscal Year 1970 program of the Foundation. However, you have a quite detailed description of the programs which was submitted to the Subcommittee on Science Research and Development of the Committee on Science and Astronautics of the House of Representatives and published as Volume II of the record of our hearings before that Committee.

In considering the requested levels of funding for the various activities in Fiscal Year 1970 it should be noted that support of scientific research and support of academic institutions (including support for the provision of computer services) significantly exceed the 1968 levels in absolute as well as relative dollar amounts. I have already called attention to the substantial increases in the National Sea Grant Program. On the other hand, it should be emphasized that in spite of such recent actions as the reduction of support of graduate students by the Sustaining University Program of the National Aeronautics and Space Administration, by the NDEA Fellowship Program of the Office of Education and through the private Woodrow Wilson Fellowships, the general support of education by the Federal Government has experienced marked growth in recent years. For this reason, only modest increases in science education support are recommended by the Foundation for Fiscal Year 1970.

Support of Scientific Research

Activities budgeted under the category of Scientific Research cover the entire spectrum of scientific disciplines and comprise about 50 percent of the budget request of the Foundation. In our budget document they are grouped under four distinct, although interrelated subcategories: *Scientific Research Project Support* ($195 million) which supports research of individual scientists or groups of scientists in all disciplines and virtually all subdisciplines of science, mathematics and engineering; *Specialized Research Facilities and Equipment* ($15 million)

which, as the title implies, provides assistance for the procurement of research facilities of a specialized nature and for major equipment, usually to be utilized by many scientists who may or may not have other support from the Foundation; five "*National Research Programs*" ($23 million) in each of which several groups of scientists from different institutions work cooperatively in pursuit of some particular objective, and *National Research Centers* ($25 million) which are operated for the Foundation by university consortia and which provide very large equipment, e.g., telescopes, and services to the scientific community at large.

The major part of the support to be provided under this category has been and will continue to be directed to basic research, as contemplated by the original legislation that established the Foundation in 1950. Basic research, the fountainhead of all science and technology and their utilization in the public interest, remains in the central position, dominating academic science and its embodiment in graduate education. The extension of the authority of the Foundation, therefore, through Public Law 90–407, to include the support of applied research at academic institutions and other nonprofit organizations, is not being interpreted as heralding a major change in direction in the program of the Foundation. It is instead a much needed relaxation of the previous limitation to basic research in the Foundation's general programs. Accordingly, the Foundation proposes to use this authority to support applied research efforts only when the work is clearly a natural extension of basic research being supported, when it is closely related to the education of scientists and engineers, or when the anticipated results can be expected to have broad applicability to science and engineering or to the solution of important problems. It is not expected that in the Research Project subcategory the support of research properly interpreted as applied in character will exceed in Fiscal Year 1970 an amount of about $10 million, or five percent of this subcategory. Certain applied research will be conducted in the National Center for Atmospheric Research and in some of the national programs, especially in the program for Weather Modification where it was formerly authorized by specific statute.

Scientific Research Project Support.—On the $195 million assigned to Scientific Research Project Support, more than 90 percent will be awarded to academic institutions to support the research of their faculty with participation by students and other scientific personnel. It is expected that almost 4,000 awards will be made, ranging in amount from a few thousand dollars to assist an individual scientist using little or no equipment, technical assistants or other services, to several hundred thousand dollars or even more for the support of a sizeable group of scientists cooperatively using a major facility, such as a particle accelerator, a telescope or an oceanographic research vessel. The duration of awards varies from one to two years or occasionally longer, the very large awards being generally limited to one year. The awards average somewhat less than $50,000 in amount and approximately 1.5 years in duration.

In the past the funds to provide scientific research project support have been subdivided among the various individual scientific disciplines. That pattern has been maintained in our proposals for Fiscal Year 1970 with only relatively small proportionate changes in every instance with the exception of engineering and the social sciences which have been given somewhat greater emphasis as a result of the Congressional action last year in authorizing applied research and specifically identifying the social sciences for Foundation support.

In addition and of particular importance will be the initiation in Fiscal Year 1970 of a program called "*Inter*disciplinary Research Relevant to Problems of our Society", which has been budgeted for $10 million. Part of the difficulty in arriving at satisfactory solutions to some of our contemporary social problems has been the diffust character of the problems themselves, requiring background knowledge and techniques from many different scientific disciplines. Let me illustrate by focusing on the condition of an individual human being, regardless of his station in life. He entered this world with his full complement of biological equipment, including his genetic apparatus; his psychological situation reflects all of the experience he has had since birth; he has received an education that represents current knowledge and understanding of the Universe and its history; he carries with him the anthropological symbols of many generations; he is almost invariably a member of one or more sociological groups, he communicates with his fellows linguistically and through an increasing variety of gadgets; he participates in the economic life of his environment, both as a producer and as a consumer; his activities are circumscribed by the legal conventions of his fellowmen and the institutions of which he is a part; and

his life is increasingly affected by technological innovations of all kinds. If he is in trouble, it cannot be assumed that he can be healed by invoking only the knowledge specific to any one of these aspects. Similar considerations apply to groups of individuals in what we call society.

Although recognizing that lack of knowledge is by no means the sole barrier to the solution of social problems which involve basic conflicts of interests and values, the Foundation believes that multidisciplinary scientific teams within or closely related to the universities can make useful and, hopefully, at times decisive contributions to the underlying knowledge that will aid in the solution of many such problems. Possible creative responses seem to require the combined talents of specialists from the various fields of science, e.g., economists, sociologists, engineers, ecologists and others. By transcending the limitations of their individual disciplines we believe that variegated groups working together under the stimulus of the proposed program can provide a major expansion in the available substantive, often very basic, knowledge required to meet the practical needs of our society, can disseminate such knowledge in useful form and can help to separate questions of fact from matters of self-interest. Although problem-oriented, to solicit the participation of the many specialists who will be involved, the program will not be action-oriented. Its purpose is that of research itself—to uncover integrated knowledge and understanding, often very fundamental, that will be useful to those who formulate and implement the policies that determine the health of our society.

This is frankly an experimental program and only experience will reveal how best to pursue it. For example, we do not know what fraction of the support will best be utilized for the continuing support of permanently organized groups as compared to more transient ones. Nor do we know, prior to broader and more intensive discussion with interested or potentially interested groups in the academic community, what the most promising fields of activity will be. In any case, however, support will, at least for the immediate future, be confined to academic or academically-related groups and will, of course, be carried out in close collaboration with other interested agencies.

Specialized Facilities and Equipment.—A matter of increasing concern to the Foundation is the provision of assistance to the scientific community in procuring requisite specialized research facilities and equipment. Although small scale equipment for individual use is widely procured through use of research or other funds, there are many larger, often commonly used, items which are indispensable to advancing the frontiers of scientific knowledge. These items range from equipment such as instruments for chemistry available to an entire department, to particle accelerators, telescopes, and oceanographic research vessels. The cutting edge of science is often dependent upon the development and availability of such new and improved tools.

However, despite the importance of providing this type of support, we have felt it necessary, with the limited funds available over the past few years, to give priority to ongoing research programs, the interruption or serious curtailment of which could cause a serious loss in both the acquisition of scientific information and the continuity of the careers of individuals.

In fiscal year 1965, $27 million was available for this program, but as a consequence of the budget stringency this allocation fell to $19 million in fiscal year 1968 and to only $5 million in the current year. We believe that it is essential that this trend now be reversed and are, therefore, proposing a conservative sum of $15 million for fiscal year 1970. Even this level contemplates only two fairly major items—the resurfacing of the 1000 foot radio telescope at Arecibo, Puerto Rico ($3,300,000) and the construction of an oceanographic research vessel ($2,000,000).

In spite of demonstrated needs no new large radio astronomy facilities have been initiated in the United States for over five years. The resurfacing of Arecibo will make it suitable for spectral line work down to ten centimeter wave length. This improvement will make it possible to attack many important scientific problems. For instance, if the resurfacing is undertaken this coming year and suitable radar facilities added in the following year, Arecibo will be available to undertake detailed radar mapping of Venus in 1972. Unless the resurfacing is authorized for Fiscal Year 1970 this will be impossible before 1975. It is essential, therefore, in order not to lose great scientific opportunities, that these funds be authorized for Fiscal Year 1970.

The Nation's progress in oceanographic research will be seriously impeded unless adequate modern research vessels and facilities are available. The existing

fleet of 31 oceanographic research vessels operated by educational or research institutions includes 16 vessels ranging in age from 16 to 35 years and not constructed for research purposes but converted for such use. The availability of modern research vessels is essential to adequate sea going laboratory facilities to ensure progress in our oceanographic research and training programs. While the construction of one new vessel will be funded from Fiscal Year 1969 funds, it is essential that this minimum construction effort be continued by providing funds for one vessel in Fiscal Year 1970.

We must in the future put considerably greater resources into making both general research equipment and major research facilities available. In addition to the general needs, there are many instances in which important potential advances are being inhibited by the lack of new types of major facilities for which the technical feasibility has been established. We believe that our request for Fiscal Year 1970 is a minimum start toward restoring this activity to an appropriate level in the Foundation's program.

National Research Programs.—The Foundation uses the term "National Research Programs" to designate certain concerted efforts which are singled out because of a national need to accomplish a specific task requiring concerted efforts in some particular field or group of fields. They may be characterized by the fact that they are designed to provide information to further possible applications, that they involve science in a specific geographical area requiring concerted logistics, or that they involve international science where cooperation abroad or coordination of the United States portion of an international effort is required.

Programs currently receiving support from NSF include the International Biological Program ($5 million), the Ocean Sediment Coring Program ($6.5 million), the U.S. Antarctic Program ($7.5 million), and the Global Atmospheric Program ($1.5 million). Also, pending the lodging of specific responsibility elsewhere, we are continuing to give concerted support to a Weather Modification Program ($2.7 million).

The Weather Modification and the Antartic Programs are of long-standing and I will not discuss them. The others are relatively new. The International Biological Program (IBP) is a broad research effort on the part of 50 nations to gain a better understanding of the changing relations between man and his environment. The National Science Foundation is the agency responsible for coordinating the U.S. portion of this important international research effort. The preliminary stages of IBP have passed, and we are now ready to begin the research program which will expand our understanding of such things as (1) the increasing size and needs of human populations, (2) the impact of these increases upon the interconnected ecological systems of the earth, and (3) the impact and resulting effects on man.

The Global Atmospheric Program (GARP), is an international as well as an interagency program designed to develop scientific information necessary for the effective establishment of the World Weather Watch. The Foundation's role in this program, for which the Environmental Science Services Administration is the lead agency, is primarily that of bringing together the talents and resources of academic science to bear on the problems to be studied, both by making grants to individual university groups and through the activities of the National Center for Atmospheric Research, which will be briefly described later.

The Ocean Sediment Coring Program utilizes the highly developed techniques of underwater drilling to recover sample cores of the ocean bottom sediments and, to a small additional depth, the underlying rock. Under a subcontract from the University of California, San Diego, a commercial firm has built and is now operating a vessel especially modified for the purpose and capable of drilling in ocean depths up to 20,000 feet. Although operations started only last July, the cores already obtained have yielded extremely important information concerning the history of the ocean bottoms, the growth of the Mid-Atlantic Ridge, and continental drift.

National Research Centers.—In certain areas of science the requisite facilities and equipment are so large, complex and costly that it is feasible to provide them in only very limited numbers, even though scienticts from many institutions may need them for their work. In other instances, research can be successfully pursued only by assembling larger groups of scientists than is logical for a single university compus. To meet these needs there evolved during and after World War II the concept of national laboratories, or national research centers, owned by the Government but operated by private—usually nonprofit—organizations.

Four such centers have been established by the Foundation which contracts for their operation with university consortia. They are the National Radio Astronomy Observatory at Green Bank, West Virginia, operated by Associated Universities Incorporated; the Kitt Peak National Observatory in Arizona and the Cerro Tololo Inter-American Observatory in Chile, both devoted to optical astronomy and operated by Associated Universities for Research in Astronomy; and the National Center for Atmospheric Research at Boulder, Colorado, operated by the University Corporation for Atmospheric Research.

The three observatories provide large telescopes for use by the astronomical community at large, approximately 60 percent of the observing time being utilized by visiting astronomers and graduate students. A relatively small scientific staff at each observatory provides scientific continuity and develops future plans. In addition to their responsibilities for conducting and supporting research programs proper, these observatories are responsible for carrying forward development of more advanced telescopes and other observing equipment; highly trained groups of scientists and engineers employed for this purpose have been very successful in this pursuit.

The National Center for Atmospheric Research (NCAR) serves several important functions. It is a laboratory at which a sizable staff of highly qualified scientists from many disciplines investigate the atmosphere in all of its phases, working especially on problems of a complex nature that require broad concerted attacks possibly only in such a large especially equipped laboratory. Again, highly trained engineers, physicists and other scientists work to advance the requisite technology, to develop equipment and otherwise to provide services for the research personnel. Significant parts of the research are joined in by visiting scientists, primarily from academic institutions who thus have opportunity to utilize the special equipment and facilities. NCAR also organizes, coordinates and partakes in major programs participated in by other institutions, especially universities. For example, NCAR's computerized six-layer mathematical model of the general circulation of the global atmosphere is a critical ingredient of the Global Atmospheric Research Program which I referred to before, in addition to which NCAR is central to the organization and conduct of important field activities incorporated in that program. NCAR is also playing a leading role in the national weather modification program.

In addition to participation in NCAR's own research program scientists from other institutions are provided special facilities such as highly instrumented aircraft, a balloon launching facility in Texas and a large computing center for the conduct of their own experiments.

National Sea Grant Program

The response to the Sea Grant Program by both the academic community and industry has been country-wide. The enthusiasm, interest, and quality of proposals from all sectors, in response to a new concept and program, established only in 1966, have been most impressive and gratifying. For example, in fiscal year 1968, shortly after funds were first appropriated for the start of the program, we received 78 formal proposals and 87 serious inquiries. The 78 formal proposals were submitted by 55 institutions in 28 states with the preponderance of content being in the fields of Food from the Sea, Engineering and Ocean Engineering, and advisory services. You may recall that the three principal objectives of the Sea Grant Act are directed to the training and education of marine science manpower, to the support of research projects, primarily applied, and to the support of marine advisory services. In fiscal year 1968, the total funding for the program amounted to $5 million for support of 27 project grants and six institutional grants.

Institutional grants, having an objective of promoting competent centers for scientific, technical and administrative components of marine science, were awarded in FY 1968 to the University of Rhode Island, Oregon State University, University of Hawaii, Texas A&M University, University of Washington and University of Wisconsin.

Important economic and scientific results already have been produced. Among these are the development of new methods of propagating commercial uses of seaweed beds by the California Institute of Technology; the dissemination of significant increases in shrimp production by the Francis T. Nicholls State College of Louisiana; the discovery of economically useful sources of sand and gravel in Lake Erie by the University of Rochester; the discovery of significant manganese deposits in Green Bay by the University of Wisconsin; and the development of a new curriculum for ocean engineering by the Massachusetts Institute of Technology.

During fiscal year 1969 with total funds of $6 million available, we plan to award a total of approximately 20 project grants and 9 institutional grants. Among the project grants already awarded is one to the University of California at Santa Barbara for partial support of research projects directed to the effective use of the marine resources of the Santa Barbara Channel. The proposal leading to this award was submitted at about the time of the catastrophic oil leak early in the year and partial support was awarded in a few days for timely research dealing with the Santa Barbara Channel.

With the substantial increase requested for appropriations the program should gather further momentum in fiscal year 1970.

Computing Activities in Education and Research

For 10 years the Foundation has provided support for the development of academic computational facilities and operations, for curricula and training activities, and for research in the rapidly developing field of computer science. That there exists a major need was recognized by the President in his Health and Education Message to Congress on February 28, 1967. He directed the National Science Foundation, working with the U.S. Office of Education, "to establish an experimental program for developing the potential of computers in education."

The Foundation is the primary Federal source of support for the development of general, campus-wide computing resources, as distinguished from computer services dedicated to the specific research needs of Federal agencies. Generally, all agencies, including the Foundation, include funds for the purchase of computing services from a general campus-wide facility in their research project grants.

Because of the growth of support by the Foundation for computers in research and education, and in response to the President's directive, the Foundation established the Office of Computing Activities on July 1, 1967. The objectives of its programs are to explore and develop the applications of computers in education and research, to strengthen and expand academic research and educational activities in computer science, to increase the number of individuals trained to use computers and improve the quality of their training, and to help academic institutions provide adequate computing services for research and education. The computing activities of the Foundation are organized in two programs: Institutional Computing Resources and Education and Research Activities. To further these goals the Foundation is working with educational institutions and other Federal agencies.

The Institutional Computing Resources program has provided assistance to many universities and colleges in developing campus computing services. The most general approach has been for institutions to establish a complex of equipment, centrally administered. Other alternatives are also becoming available: networks of teletypewriters or other terminal devices, several independent or linked computers, participation with other institutions in sharing a major computing resource, or the purchase of commercial services. There is further a growing interest among educational institutions in acquiring small specialized computers for use in on-line process monitoring, data acquisition, and laboratory instruction.

The cost of computing activities varies widely. Many campuses provide more than a dozen computers of different types for educational and research use, and annual computing costs may vary from tens of thousands to several million dollars. The transition to an expanded level of service can place a severe strain upon an institution's financial resources, and the Foundation offers partial financial support to help colleges and universities during this transition period. Grants are normally limited to a period of three years, but may be extended for an additional two years.

An important component of the Education and Research Activities program concerns research, education, and manpower in the field of computer science. Research activities in computer science supported by the Foundation range from highly theoretical studies in automata and programming languages to the exploration of novel computer systems. On the other hand, a shortage of trained computer scientists, programmers, and opeartors exists throughout the Nation. The situation in colleges and universities is particularly acute, and an important objective of this program is to help overcome the shortage of computer scientists by strengthening and expanding related academic activities, including research.

The Foundation has also given priority to establishing a new program for exploring the educational potential of computers. Its activities fall into three

classes: Curriculum Development and Training, Instructional Management Techniques, and Regional College Computing Activities.

New curricula must be developed to reflect the current uses of computers in the sciences at both the graduate and undergraduate levels, and to permit an interchange of computer-related course material among institutions. It has been proposed, for example, that new courses be created to permit the student to simulate on the computer the performance of complicated and often expensive laboratory experiments or to explore at an early point in his training complicated theoretical models. The Foundation has also begun a number of efforts to help redevelop curricula in the sciences in order to utilize the computer's advantages. Through other grants teachers are being given opportunities to learn to use computers effectively and to understand the application of current developments in computer-based instruction to their fields.

Among the applications of computers to Instructional Management, experiments are being conducted in their use as teaching machines to present flexibly controlled instructional material, sometimes referred to as computer-assisted instruction. Other experiments are concerned with testing how the computer may provide the teacher with more direct guidance information about student progress. However, these experiments also reveal inadequacies in the current state of technology and in understanding of the basic process of learning. Grants have been made to encourage the study of these problems, and the Foundation is also planning to join with other agencies in developing coordinated support for a more sustained effort in this area.

Most colleges have neither the resources nor personnel to develop adequate campus computing centers. The Regional College Computing Activity is addressed to this problem. New developments in computing have made it possible for individuals and institutions to share in the use of remotely-operated computers. The Foundation undertook 10 experiments in FY 1968 to test and demonstrate the merits and limitations of regional computing network concept in education. These pilot projects were designed to address such questions as: the means for faculty at small colleges to learn about computers and to explore new curricular materials being developed elsewhere; the useful computing languages, computing services, and their costs; and the potential benefits from cooperative activities among institutions. To date, 57 grants for regional college computing activities have been awarded; they have involved eight major universities, 82 participating colleges, and 23 secondary schools located in 25 States.

In FY 1968 the Office of Computing Activities obligated a total of $22 million to provide direct and indirect assistance to universities, colleges, secondary schools, and educationally-related institutions. In that year 42 grants totaling $10,600,000 were awarded through the Institutional Computing Resources program and another 131 grants totaling $11,400,000 were awarded for Education and Research Activities.

Because of its reduced appropriation, in FY 1969 the Foundation expects to obligate only $17 million. The lower level required reducing the level of support for the Institutional Computing Resources program to $6 million and slightly reducing the level of support for Education and Research Activities to $11 million. It is felt that high priority must be given to restoring the FY 1968 level of activity for Institutional Computing Resources; accordingly, the FY 1970 budget request of $22 million includes $11 million for this program and an equal amount for Education and Research Activities.

Institutional Support for Science

Recognizing that the quality and quantity of research and science education in the U.S. is dependent upon the strength of the country's universities and colleges, NSF support to the academic institutions is not only substantial, it is varied in purpose and mechanism. Large sums are granted for research as well as for training, and for specialized facilities and equipment and computer assistance. Some of these, e.g., support for computer facilities, have institution-wide impact. In addition, the NSF has established a variety of programs that are explicitly designated as institutional programs.

Maintenance of institutional strength is the goal of two of these programs, "Graduate Science Facilities" ($8 million) and "Institutional Grants for Science" ($18 million). Institutional Grants for Science provide general purpose grants to institutions, the amounts being determined by a formula that uses as a base the research support received during an appropriate year. Each institution uses the funds to sustain its science activities in accordance with its own particular requirements, priorities and judgments. Heretofore, the awards have been made in

early June, on the basis of research support by NSF alone during the 12-month period ending on the preceding March 31. Beginning in fiscal year 1970, the Foundation will base the formula determining the size of the grants on the total research support from all Federal agencies except the Public Health Service, which has its own program of this type. Since the only feasible 12-month period to use for this purpose is the fiscal year, it will be necessary to postpone the awards this year until autumn. Hence no funds will be used for this program in fiscal year 1969, accounting for an $18 million increase in Fiscal Year 1970 compared to Fiscal Year 1969.

In addition to maintaining institutional strength, the NSF also tries to increase it by providing a spectrum of assistance through its University Science Development ($30 million), Departmental Science Development ($10 million), and College Science Improvement Programs ($8 million). Each of these programs is suited to groups of institutions of differing type, size and functions.

The University Science Development Program (USD) is designed to provide assistance on a fairly broad front to a limited number of univeristies which, though not now among the very foremost in science, demonstrate definite potential for moving into the highest levels of scientific capability. Since the inception of the program in 1964, USD grants amounting to almost $125 million have been made to 30 institutions in 21 states.

The class of institutions for which the Departmental Science Development Program is designed includes those that have not reached high levels of overall quality, but which have attained significant strength and have capacities for marked improvement in individual departments or well-defined single areas of science. Approximately 355 emerging institutions are considered to be in the group eligible for participation. The Departmental Science Development Program became operative in January 1967. Through the end of fiscal year 1968, grants totaling $14 million had been awarded to 26 widely distributed institutions.

The College Science Improvement Program, initiated in January 1967, is a development program for predominantly undergraduate institutions. As such, it complements the Departmental and University Science Development Programs which serve institutions with a major commiment to graduate instruction and research. By means of grants of up to three years, an institution devoted to undergraduate education may engage in a wide variety of activities designed to permit major improvements in the quality of its science education. Since its inception the program has awarded grants totaling approximately $17 million to 96 colleges in every region of the country.

SCIENCE EDUCATION

In carrying out its responsibility to initiate programs to improve the scientific research potential of the country and to develop and encourage the pursuit of a national policy for the promotion of education in the sciences, the Foundation supports education activities which have as their specific goal an increase in the number and competence of scientists and engineers in this country and improvement in the quality of science education at all levels. Programs devoted to this end cover a broad range of activities that account for almost one-quarter of the total budget.

Advanced science education is an obvious concern because at this educational level the student acquires competence for future scientific achievement. Quality performance is critical and every effort must be made to assure an appropriate education opportunity to those individuals who have the capacity and intellect to achieve a mastery of some aspect of modern science. The budget proposes a total of almost 9,000 formal fellowships and traineeships, principally at the graduate level, but with a modest number for immediate postdoctoral and a few even more advanced individuals. These awards are available on a competitive basis to all properly qualified U.S. scientists either through national competition or through Foundation-sponsored traineeships administered by graduate institutions. In addition, we support a number of science seminars and special projects related to the improvement of the quality of graduate education through curriculum improvement or otherwise.

At the undergraduate and precollege levels the Foundation exploits its knowledge of and rapport with the scientific community, including creative research scientists, to bring their talents and experience to bear on improving the quality of science education in general with emphasis on its substantive content. The major efforts directed toward these ends are designed to:

Bring about improvement in the quality of instructional programs at the elementary, secondary and college levels through the development of better courses and instructional materials, including partial support of equipment to implement improved undergraduate courses in colleges and universities; curriculum improvement projects are highly organized and utilize the varying talents of active scientists, teachers and administrators in a manner never done before.

Improve the competence of elementary, secondary and college teachers through especially designed instructional programs formally designated as "institutes", most of which are held during the summer recess. Some, however, are held during the academic year providing opportunities for those with leaves of absence to study, while still others provide opportunities for instruction for in-service teachers in the evenings and on Saturdays.

Provide for the identification of high ability senior high school and undergraduate students and appropriately support them in meaningful enriched experiences in science, including introduction to research. Several thousand high school and college students are given such opportunities in the summer and many undergraduate students work with research scientists during the academic year.

Support "college-school" cooperative projects through which colleges and universities assist elementary and secondary schools and school systems install improved curricula and train staff; this is presently a growing component of the program.

Include a more extensive involvement of junior colleges and technical institutes in relevant, existing programs.

Accelerate the development of science capabilities of predominantly undergraduate institutions; the College Science Improvement Program budgeted under institutional programs is an important part of this effort.

All of these programs, though seemingly scattered, are complementary to each other.

Some idea of the impact of the Foundation's programs on pre-college education can be given by the fact that secondary school teacher institutes funded in FY 1970 will give training opportunities to approximately 33,000 secondary school teachers, in addition to which the Cooperative School Science Program will provide such opportunities for approximately 6,000 secondary and 1,800 elementary school teachers. It is estimated that something like half of the secondary school science teachers in the country have had such opportunities in the past. Another important statistic is that more than three million secondary school students are now utilizing curriculum materials developed under Foundation auspices; these represent a substantial fraction—in some fields more than half—of all high school science students study physics, chemistry, biology and mathematics. Each year almost six thousand of the brightest students are given opportunities to partake in research or other advanced science activities under the guidance of experienced scientists.

Each year between seven and eight hundred colleges and universities receive support from the Foundation's programs, including participation in the Secondary School Teacher Institutes. Approximately 360 received support from the Instructional Equipment Program along in FY 1968.

SCIENCE INFORMATION

The Foundation's science information program provides financial assistance to such organizations as scientific and technical societies, universities, research institutes and science museums in order that they may maintain their present services at an adequate level, design and acquire science information systems based on modern technologies and systems design, or undertake work that will lead to more effective information services in the future.

The objective of this program is to provide adquately for the information needs of U. S. scientists, engineers, and graduate students by facilitating the flow of scientific information, by encouraging the development of a system in each major field of science and engineering, and by fostering the development of a network of such information systems so that scientists and engineers will be able effectively to obtain information necessary for research, development, or education activities.

Total obligations in 1968 were about $14.4 million. Approximately 56 percent of the total was allocated to Information Systems Development, about 22 per-

cent to Information Services and Publications, about 9 percent to Research and Advanced Development, and the remainder, 13 percent, to Foreign Science Information and Translation. The total estimate for 1969 is $11 million and that requested for 1970 is $13 million.

The Chemical Information Project will illustrate the types of items included in Information Systems Development. The significant information unit in chemistry is the chemical compound. To develop an effective computerized system it was necessary to devise a method for input of the diagram of the chemical compound structure into the computer; to devise methods of identifying these structures and substructures in the computer; to develop programs to tie these compound structures to the information about them; and to develop methods to retrieve this information for use by scientists and engineers. Ten years ago none of these operations could be accomplished. A special typewriter for constructing diagrams had to be devised; programs for the computer had to be written, and a special output system had to be built. Among contributors to the present experimental chemical compound registry system were IBM, the Walter Reed Army Hospital, several additional units of the Army, several chemical companies, the National Bureau of Standards, the Moore School of Electrical Engineering at the University of Pennsylvania, and the American Chemical Society. The cost for the input of a chemical compound in the registry system, because of improved techniques, has been reduced 25 percent in the past 3 years. There are between 3 and 4 million known compounds, while thousands of new ones are being discovered each year.

Prototype experimental use is being made of this developing system by organizations representing government agencies, industrial establishments, universities, and foreign countries. Programs to improve information systems are also in progress in physics and psychology, while preliminary information system studies have been started in mathematics, the life, environmental, and social sciences, and engineering.

These comprehensive discipline-oriented information systems cannot completely meet the variety of information requirements of scientists and engineers located on university and college campuses. The Foundation is, therefore, providing assistance to several university centered projects. One of these projects is located at Stanford University. Users can search the SPIRES (Stanford Physics Information REtrieval System) file from their offices or laboratories. More than one person at a time can use this system. Users have the option of searching by author, title, keywords, and dates. The SPIRES system can be expanded to serve scientists and engineers in the surrounding area; the system will thus ultimately be a regional information system, capable of connecting users to a variety of information files.

Under the program in Information Services and Publications more than 60 scientific journals, including the establishment of 12 new journals in fields inadequately served, have received Foundation support from time to time since 1958, and assistance has been provided in the publication of more than 240 monographs in 13 scientific disciplines and fields, ranging from astronomy and biochemistry to zoology and anthropology. During the same period, the Foundation has in similar fashion provided support for more than 30 abstracting, indexing, and bibliographic services.

Research, advanced development, and the study of methods for evaluating information systems are supported by the Foundation. A number of projects supported in the past have led to improvement in information activities. Foundation supported experiments have resulted in new techniques for handling graphics, such as chemical structures and mathematical and physical formulas in computer-controlled composition of scientific texts. Problems currently being investigated with Foundation support include: automated techniques and systems design for a research library of the future; computer techniques for indexing articles; computer and video techniques to assist the human indexer to index scientific articles and books faster; and methods by which large information systems can be connected into an information network.

About one-half of the world's scientific and technological literature is published in languages unfamiliar to most scientists in the United States. The Foundation, under its Foreign Science Information and Translation Activities, has one translation program conducted in the United States and another conducted in excess foreign currency countries. Nearly 516,000 pages of scientific and technical literature have been translated in the 10-year period from 1959–1968. Because the translation program conducted in excess currency countries

has proven useful to scientists and engineers, the Foundation is requesting authorization to expend the equivalent of $2 million in these excess foreign currencies in 1970. In addition, the Foundation has supported the preparation and publication of more than 5 reference aids, guides and directories. Examples include *Japanese Periodicals Index* and *Directory of Selected Research Institutes of Eastern Europe.* The Foundation also supports bilateral exchange of information and participation in international governmental and nongovernmental organizations. An example of Foundation support for United States participation is provided by the Committee on Data for Science and Technology (*CODATA*), a coordinated international program for the collection of critical data, organized two years ago. CODATA is located in Frankfurt, West Germany, and is supported cooperatively by the major industrial countries.

The immediate program of the Foundation includes: continued support of the developing information systems in chemistry and other disciplines; continued support for information services and publications, including the Science Information Exchange, as well as abstracting and indexing services, and primary publications; continued support, both in the United States and abroad, for translation of Slavic, Japanese, and Chinese scientific and technical literature; and support for ongoing experiments in universities to improve their research libraries and to make better use of the large national information services in chemistry, physics, and engineering.

INTERNATIONAL SCIENCE ACTIVITIES

Science cannot be confined within national boundaries. No country has a monopoly on scientific brains or ingenuity· Moreover, some phenomena of nature can be observed only in particular areas of the earth. Sometimes, progress in science is dependent upon the correlation of worldwide observations.

As a consequence of these factors, activities involving science across national boundaries are carried on widely throughout the Foundation, as well as through a separate Office of International Science Activities charged with administering specific international cooperative scientific programs as well as with general coordination of all international activities. Thus, in our regular research programs awards are sometimes made to U.S. institutions for work which must be done partly or wholly abroad. An example would be an anthropological study in Africa or astronomical observations carried on by the Cerо Tololo Inter-American Observatory in Chile. More directly, awards are sometimes made to a foreign institution because the research being carried on is of particular significance or because it affords an opportunity for American scientists to conduct specific research or be trained in a manner not available in this country.

Similarly, the Foundation's education divisions find that it is often most appropriate and desirable for Fellows receiving awards to undertake their study in foreign institutions where specialized scientific work is being pursued. This is particularly true of the older and most experienced scientists receiving fellowships, although a fair proportion of those who are about to earn or have just received their doctorates, also find it desirable to study abroad for a period at this stage in their careers in order to pursue the particular studies in which they wish to engage. Moreover, universities in this country find it desirable to have foreign scholars visit their campuses for relatively short periods of time in order to bring the knowledge of work in their fields abroad to this country. This we also support to a limited extent.

While articles contributed to scientific journals by U.S. scientists exceed in number those contributed by the scientists of any other single nation, his output represents only a fraction of total world literature. Accordingly, our Office of Science Information Service provides for translation and dissemination of foreign journals in this country.

In addition, however, to these and other types of participation in international science, which are funded as integral parts of the general activities of the Foundation, we support through a separate budget item of "International Cooperative Scientific Activities" certain specific activities. These activities include support of Cooperative Science Activities, Science Organization Programs, and International Travel. These programs aid in the strengthening of science and in some instances also further general U.S. national interests abroad. These activities encourage professional collaboration and contact between U.S. and foreign scientists, facilitate scientist-to-scientist communication across international boundaries, and support U.S. participation in and assistance to key inter-

national and foreign activities for the planning, coordination, and improvement of international scientific programs.

Cooperative Science Activities embrace a number of formal cooperative arrangements between this and other countries, for example, the U.S.-Japan and U.S.-Italy Cooperative Science Programs, as well as a number of informal university-to-university agreements with institutions in countries where no formal government-to-government agreements exist. In addition, international science exchange programs are undertaken to encourage and increase contact and involvement in research, science education and science information activities by providing support for U.S. scientists to go overseas while foreign personnel come to this country. Formal exchange agreements with several East European countries, administered for the Foundation by the National Academy of Sciences, constitute an important part of this program. Under these agreements each country pays the salaries and the international travel of its own scientists while the host country funds their local travel and other appropriate expenses.

The Foundation's *Science Organization Programs* assist the work of international scientific unions and similar nongovernmental scientific organizations which came into being to promote professional, technical, and scientific interests and objectives of national scientific bodies. These international unions have proved to be remarkably useful and versatile as means of communication among the scientists of the world. In recent years, such intergovernmental organizations as UNESCO have increasingly called upon the scientific unions for advice and for scientific help. For instance, an international conference on the problems of environmental pollution was recently held by UNESCO with substantial professional help from the International Council of Scientific Unions.

Support for international travel activities, budgeted as part of International Cooperative Scientific Activities, is managed by the research and education divisions of the Foundation. This program supports the travel of scientists to international meetings and congresses. Attendance at such meetings has paid off manyfold in better informed scientists, better scientific programs, speedier development of results, and, last but not least, in better international understanding. The Foundation exercises rigorous control over support extended by selecting the most significant meetings—a fraction of the total number—and then selecting the scientists the Foundation will support to attend these meetings, using the normal Foundation evaluation processes. Care is taken to ensure that brilliant and promising young scientists are assisted in attending meetings as well as older and more distinguished ones.

Finally there is another type of activity which is among those envisioned by the increased authority for international activities given by P.L. 90–407. At the request of and with funds made available by the Agency of International Development (AID), the Foundation is working to assist developing countries in their efforts to improve their educational programs in science through applying significant advances which have been made in science education in the U.S. The most important project of this type is the Foundation's Science Education Improvement Project in India which is assisting the development of improved science teaching methods in that country. Some idea of the magnitude of this effort can be gained from the fact that 178 American consultants took part in 136 summer institutes for secondary school and college teachers in 1968. Smaller numbers assist in follow-up activities in the schools and colleges themselves.

Other efforts are being supported to make available to the developing countries improved methods for training and educating their technical and scientific manpower. Without an indigenous cadre of trained personnel, progress in any country is severely handicapped. In the years to come further and far greater efforts must be made in this direction.

PLANNING AND POLICY STUDIES

The Foundation's Planning and Policy Study activities are carried out with the objective of developing a more thorough understanding of the changing character and requirements of the national scientific enterprise. These activities include extensive analytical and data compilation efforts related to the resources required for the national scientific endeavor—manpower, institutions and funds. Other analytical studies deal with such issues as: the needs of various sciences, the needs and characteristics of academic science and the development of the basic methodological tools for science planning and policy making. Thus, this particular NSF program is carried out on a broad national basis for the benefit of all of those active in science policy formulation. Obviously the results of these

studies are of great utility in the development and implementation of the plans and policies of the NSF.

The planning and policy studies supported by the Foundation are grouped into five budgetary sub-categories:

Studies of Scientific and Technological Manpower Resources concentrate on the production of statistical and analytical information on the characteristics, utilization, supply and demand of the nation's scientific and technical personnel.

Studies of Educational and Research Institutions analyze various aspects related to the role and health of these enterprises; because of its great interaction with the academic community the Foundation's efforts tend to concentrate on matters related to academic science—students, facilities, finances, etc.

Studies of Public and Private Funding of Science and Technology obtain information on the performance and financing of research and development in various sectors of the economy.

Studies of the Interaction of Science and Technology with Society try to illuminate the processes through which science and our society interact; this activity also concentrates on the strengthening of science planning and science resource utilization, particularly on the state governmental level.

Science Policy and Program Studies deal primarily with the identification and analysis of key issues and problems of contemporary science policy. In this activity the Foundation tries to stimulate and utilize the intellectual talents of the academic community to address itself not only to science policy issues but also to train young people to deal with these issues with a good background in both the natural and social sciences. Also included is support of the Committee on Science and Public Policy of the National Academy of Sciences and the equivalent committee of the National Academy of Engineering including their evaluation of the needs of various fields of science.

This relatively broad program is carried out both by in-house Foundation staff and through extramural grants and contracts. These activities will require $2.9 million in FY 1970. It should be pointed out that 60 percent of this budget will be required by projects carried out in accord with statutory requirements, such as the National Register of Scientists and Engineers, and for long-established periodic efforts, such as regular periodically conducted surveys.

Program Development and Management

I shall not discuss the organization of the Foundation, since it follows generally the program structure that I have outlined and that forms the detailed basis for the Fscal Year 1970 funding request. I do wish to mention, however, that the staff of the Foundation is planned to average 966 employees, a figure that is not substantially greater than in 1963. The administartive costs of operating the Foundation are estimated at 3.3 percent of total obligational authority. Approximately 80 percent of these costs are allocated to the compensation and related benefits of the staff and of the many advisors who assist the Foundation in its work.

SUMMARY AND OUTLOOK

In this highly condensed overview I have tried to present a number of the highlights of the Foundation program and the plans for the coming fiscal year. I have wanted to convey to you an impression of the exceedingly broad, complex, and varied nature of this program. The work of the Foundation, however, is the response to a need; it is not imposed upon the academic or scientific communities. This need is real and it is rapidly growing. During the past few years the Foundation, and indeed the Federal Government, has failed to keep pace with this need. The many reasons for budgetary caution today are well understood. But when this caution is focused on one of the great sources of American strength, the implications for the future of the Nation are serious.

Within the next few years it will be necessary not only to increase the general level of support but to take steps to meet some specific needs which have been aggravated by the necessity of neglecting them to keep the general program going. In particular, I believe that greatly increased investments will have to be made to provide more equipment and especially to provide such very advanced specialized facilities as large radio telescopes and oceanographic research vessels. Another rapidly growing need is for computers, both to replace older models with higher capacity ones developed in recent years and to make computer services more generally available. There is also a growing, almost

crucial, shortage in universities with respect to general laboratory space, Federal funds for which have been held at a minimum in the past few years.

Over the longer range the outlook becomes even more difficult. Two estimates of the future assume special importance:

> It is projected that the number of the Nation's graduate students will double by 1980, reaching a total of about 1.3 million by that time. Of the order of one-third of these students are and will be enrolled in science and engineering.
>
> Because of both the rising graduate population and the ever increasing unit costs of science, the anticipated annual cost of graduate education in the scences is expected to quadruple during this same period.

In spite of increased contributions to higher education, and especially graduate education, by philanthropic organizations, by industry, and by State and local governments, the rate of such increases cannot match this escalation of cost. All recent studies agree that a substantial share of the funding needed for this period of dynamic growth will necessarily be derived from the Federal Government. At the same time the Federal agencies that have constituted the major support of academic science and graduate education in the sciences will continue to experience changing priorities, the maturing and termination of specific programs, and uncertain appropriation patterns. Each of these factors can and does have unfortunate, although inadvertent, effects on the stability and effectiveness of the educational process, effects that are ultimately felt at all educational levels. If the Foundations is to be fully effective in its role of strengthening the scientific research potential of the Nation and mitigating these effects, I believe that, as additional resources are made available for academic science, a larger proportion than has been the case in the past should be assigned to the Foundation. This I believe would help provide a more stable base to the academic science enterprise—a base upon which other agencies could build in fostering research of particular concern to their own responsibilities.

In conclusion, I believe the Fiscal Year 1970 budget request of the National Science Foundation to be a balanced one and one that is well conceived to meet the immediate needs that confront us. The Foundation welcomes your review and consideration.

Thank you.

DISTRIBUTION OF PROGRAMS

Senator PROUTY. Thank you, Mr. Chairman.

Dr. Haworth, I think a frequent criticism voiced by Members of Congress is that a very substantial amount of the Foundation's program grants go to universities and colleges in a relatively few States. I would like your comment on this, because I hear this criticism frequently.

Looking at the figures, for example, California has $54 million plus; New York, $48 million; Illinois, $56 million, and Massachusetts, $35 million plus.

Dr. HAWORTH. Well, I can discourse on that at some length. I will try to be as brief as possible.

The Foundation's support of its work of, say, research project grants, of traineeships, of any number of things, is based, of course, primarily on the qualifications of the people and the promise of the work that they propose to do. Now, most of the high-quality people are, of course, found in the great universities. These universities are concentrated. They have been concentrated not because of Federal Government support. They were concentrated long before there was any Federal Government support.

If one analyzes the sorts of figures that you have given, which are quite true, of course, one finds that, for example, the support per graduate student or the support per Ph. D. produced does not vary greatly among the States. There are differences, Massachusetts and California are on the high side. But not by anything like the same ratio as the absolute amounts.

Nevertheless, it does concern us, just as it concerns you, and we have been taking steps as best we could to try to improve the situation. Not, however, by taking funds away from the places that will presently make the best use of them, but by trying to build upon potential—to strengthen the institutions in other places. And I very firmly believe that there should be very strong universities in every region of the country, I believe there should be a strong university in every State. I believe there should be a strong university in every metropolitan area.

Now, the reasons are varied. The reason I select State, for example, is that a great university has a tremendous impact on the entire life of the State. It has a tremendous influence, for example, on the educational system of the State, and I do not mean just the higher education, but from the ground up.

Similarly, a great university has more local impact if it is in or adjacent to, though it is probably better not to be immersed in the center of, a great metropolitan area. Not only are these the kinds of impacts that are statewide in the sense of influencing the ways of thinking, the educational system, and so forth, but it also gives opportunity for local people to make use of the university, to commute, either for part-time attendance or to use the library facilities or to confer with the faculties, or things of that sort. So I do believe that we should strengthen institutions in many parts of the country and in many localities.

It is to precisely this end that we have these programs that I spoke of earlier, that we call the development programs. There are three, the first, which is now 4 years old, is called the university science development program. In that program we accept proposals from Ph. D. granting universities only. Those proposals must be based on well-thought-out plans, with some detail as to just how they propose to go about improving the quality of their science activities, both research and educational, in some fairly broad spectrum of their science activities. That is, not just one department but several departments. In general—in fact, never—is it the entire science spectrum. But it varies from, say, three to a half dozen or even occasionally eight or 10 departments.

These proposals are made to us. They are analyzed by our staff. The universities are visited by teams partly made up of our own staff, partly made up of advisers of other parts of the community—industrial people and university people and so on.

Then there is finally a panel of about eight or 10 people who meet around a table for a day and having had opportunity to study these proposals they advise us as to which ones of these look really promising. Within the limits of our financial ability we then give grants to the best ones. They have averaged about $4 million. They cover a period of 3 years. During that period, then, the university improves its faculty, buys equipment, and in some instances, it builds laboratories. It helps graduate students, it brings in postdoctoral people for a brief tenure, and so on. It is then possible for them to apply for a renewal of 2 years, at the end of which they are on their own so far as those departments are concerned.

They could, after that, apply for a development grant for some other part of their science program but that part we have taken care of.

Now, the universities provide even more support than do we for these improvement programs. And it is up to them to be sure that their future financial resources are such that they can continue this program once it is underway.

In this first program, we have given grants to 30 universities scattered all over the country, and a few have now been renewed. We will give two or three more new grants by the end of this year and hope to give a few next year.

The second program is called the departmental science development program. It has similar aims, but it is more modest and focuses attention on a single department instead of a broader spectrum. The concept here is that, these grants will be predominantly to institutions that are not quite as far along as the ones that get the first type of grants. Eligibility extends to institutions granting masters degrees. I should have said and I guess it was implicit in what I said that the very best universities—and we leave it to them to define whether they are among the very best—are not eligible. Harvard, for example, is not eligible for development grants in either of these categories.

Now, our hope with respect to the departmental program, which is only a couple of years old, is that this will enable institutions to build up strength in an already potentially strong department and that this will then, not only add strength through the immediate direct effects on that department, but it will give an incentive and a target for the rest of the university as it tries to build itself up to higher quality. Through fiscal year 1968, 26 grants totaling $14 million have been made in this program approximately 15 more will be made this year.

Then finally, there is a similar program that is confined to non-Ph. D. granting institutions. It is called the college science improvement program and is aimed primarily at undergraduate education, although many of the recipient institutions have master degrees programs. Almost 100 grants have been made in this. and again, they are scattered all over the country. We are trying by this mechanism to build up strength where there is potential for strength. and where greater strength is needed.

Senator Prouty. Well, I hope you will do this as rapidly as possible, because I think it is most important.

I have one comment that I feel I must make as a Senator from Vermont. It is to point out that a State which is smaller than mine, Wyoming, received double the amount of funds which were made available to Vermont.

Incidentally, the president of the University of Vermont subsequently become president of the University of Wyoming. I am sure in his judgment, the schools are two of the finest in the country.

But I just wanted to make the fact known so my friends from Vermont will realize that I am standing up for their interests. In my state we have some of the finest universities and colleges, in my judgment, in the country, although some of them are small.

I have just two or three questions I want to ask you, because you have touched on what I had in mind.

H.R. 10878, while reflecting on the administration's desire for authorization for general purposes, differs from the legislation I introduced by the inclusion of section 5, which requires that the Foundation:

Shall keep the Committee on Science and Astronautics of the House of Representatives and the Committee on Labor and Public Welfare of the Senate fully and currently informed with respect to all of the activities of the National Science Foundation.

Do you know to what Federal agencies similar language currently applies?

Dr. HAWORTH. I know of one, Senator Prouty; namely, the Atomic Energy Commission. There is a similar section in the Atomic Energy Act. But it is in almost, if not exactly, the same words. That is the only one I know of. There might be others.

Senator PROUTY. Well, what effect would the language contained in section 5 have on the Foundation's operations?

Dr. HAWORTH. It depends, of course, on interpretation. We believe that we do keep the committees well informed and especially in view of the new legislation and the increased interest—the Foundation on the part of the House committee and of this committee. We are being and expect to continue to be more and more vigorous about doing this sort of thing.

I believe that we should keep the committees informed as to actions that we have taken. For example—and this is not confined to these committees—we provide on a daily basis a list of all the grants and contracts that are made. We provide that to all Members of Congress.

If properly interpreted, I do not believe that this would result in many things that we would not expect to do anyway. It would, in my opinion, however, be possible at some future time for it to go too far. In the sense of keeping fully and currently informed on the deliberations, the sort of internal discussions, the factors that we ourselves are not yet sure of, and so forth. It simply depends on how vigorous, how detailed the interpretation is.

I believe that the situation will be better—and I will be very frank—without that section.

Senator PROUTY. I may find after further study that I do not agree with you. I am confident the committee will take this matter into consideration. I have one more question.

LENGTH OF AUTHORIZATION

Would your activities be better served if Congress were at this time to authorize funds in fiscal 1971 as well as 1970? In other words, a 2-year authorization?

Dr. HAWORTH. This is a difficult question, Senator, at this moment; as a general thing, I would be highly in favor of 2-year rather than 1-year authorizations. And I would have been happier had the bill passed last year been a 2-year authorization. However, to attempt to do a 2-year authorization at this time has some difficulties in the sense that there has not been the proper planning, thinking through, or things of that sort, certainly not on our part and as far as I know, not on the committee's part, to do that. I would suggest that a very good step would be to authorize 1-year appropriations now and to change the legislation so that in the future it would be 2 years.

Senator PROUTY. Thank you.

Thank you, Mr. Chairman.

Senator PELL. Thank you, Senator Prouty.

Last year at this time I was a little concerned about the treatment given to the sea grant college program and I must say in the intervening period, I think you have done it proud, that it has moved along and done really as well as could be expected in view of the tight conditions of the budget. I was interested, in your statement, to notice that you brought out the immediate rewards from applied research. The manganese nodules discovered in Green Bay for example have a value greater than the cost of the total sea grant college program. I imagine other projects will add considerably more to the immediate rewards we derive from the program. I would hope that the Foundation under your successor will continue to expand the program which returns so many immediate benefits to the public.

What is your view with regard to the recommendations of the President's Commission on Marine Science? Do you think there should be a wet NASA and if so, how should it be set up?

Dr. HAWORTH. I have mixed feelings on it, Senator Pell. There certainly would be many ways in which this could result in more concerted efforts and so forth. But I do have questions about it, in particular questions about the combination of the marine sciences and the atmospheric sciences.

Also, as you well know, there is a great deal of discussion about organization of the executive branch in terms of science as a whole, science and education as a whole. I think these two things should be thought through together. I do not believe that one should proceed to legislate the specific recommendations of Dr. Stratton's commission out of the context of the entire problem. By the way, that is a brilliant report, in my opinion.

Senator PELL. It is excellent.

Dr. HAWORTH. Without thinking through all the ramifications with respect to the other aspects of science, in particular, I question this welding together of these two. And of course, it depends in large measure——

Senator PELL. Welding together what two?

Dr. HAWORTH. Atmospheric and the marine sciences.

It is true, of course, that weather is, perhaps in the primary sense, generated at sea, and there is great interaction between the atmosphere and the water and so forth. But the continents are pretty big, too. And the questions of rainfall, questions of air pollution, and things of that sort are pretty remote from the major interests of the marine sciences.

In any case, it depends, of course, on how all-incluusive such an agency is. I for example, would not agree that there should be an all-inclusive science agency, an all-inclusive science and technology agency. I believe that the agencies with specific missions should support research, even basic research, for a number of reasons. First, only they can judge what their own needs are and emphasize those areas of science, even down to fair detail, that are most important to them. Second, if they are going to be effective users of science, they must themselves understand science, and the opportunities, and unless they have scientific activities and scientists of their own, they cannot really understand it in full. Third, by having science programs of their own, they have access, then, to the outer world of the scientific community. They have people who are interested in their programs

who can advise them on their own specific need and so forth. So I am in general fairly cagey about anything that is too all inclusive.

Senator PELL. Thank you.

Thank you, Dr. Haworth. I realize in a sense this is your valedictory appearance here. You have certainly served our country and the Foundation very well.

I would like to direct my next question to Dr. Handler.

In connection with Dr. Haworth's successor, and I do not mean to embarrass you in any way, I am not going to ask you your view with regard to the pros and cons of the ABM, but how can we separate, in your view, this appointment from private and public opinion, if this can be done?

Dr. HANDLER. We have a statement from the President to the effect that the problem will not exist on the next go-round of this activity. I take that statement in good faith, sir.

Senator PELL. I read that statement. I thought it an excellent one. It takes a big man to admit an error in his staff organization. I thought the President was both courageous and correct in that fine statement. I would hope that there would be no such requirement made of his successor. In your job, is it one of your functions to recognize the quality of choices or does this come out of the President?

Dr. HANDLER. The act asks that the Board recommend to the President.

Senator PELL. So you have the responsibility?

Dr. HANDLER. That is what has happened in the previous cycle of this activity and we will do it again.

Senator PELL. And you have given one name or several?

Dr. HANDLER. We have given the President a choice.

Senator PELL. You have given several?

Dr. HANDLER. Yes.

Senator PELL. All right. I thank you very much for your appearance.

Senator Eagleton.

Senator EAGLETON. I have no questions.

Senator PELL. Well, then, the subcommittee is adjourned subject to the call of the Chair.

Dr. HAWORTH. Could I say one thing?

Senator PELL. Yes, sir.

Dr. HAWORTH. I would like to thank you, Senator Pell, for your very kind words to me personally. I certainly enjoyed our relationship. I am sorry to see that it, to know that it, will diminish.

Senator PELL. Thank you very much.

The hearing record will be left open for statements of those who could not attend this hearing and for other pertinent material submitted for the record.

(The material referred to follows:)

QUESTIONS FOR DR. HAWORTH FROM THE SPECIAL SUBCOMMITTEE ON THE NATIONAL SCIENCE FOUNDATION TOGETHER WITH THE RESPONSES FROM DR. HAWORTH

(Questions 1 through 14 relate to the proposed new program of interdisciplinary research relevant to problems of our society)

Question 1. What are some specific examples of the sorts of projects which might be supported by this program?

Answer. Detailed examples of research to be supported under this program are difficult to give since the program has not yet begun and no formal proposals

have yet been received. Also, one feature desired is the stimulation of unusual and creative new approaches to public problems through the combined efforts of scientists with disparate backgrounds. Clearly, it is difficult to forecast with precision what these approaches will be. Typical examples of broad problem areas might include:

1. Cultural and social consequences of changes in technology.
2. Structure of the urban environment.
3. Environmental quality in modern society.
4. National manpower needs and incentive structures.
5. Economic and social consequences of peace and war.
6. Technology and economic development.
7. Social implications of modern information handling techniques.

It must be stressed that this listing is meant to be suggestive, and not all-inclusive. Research in such areas naturally brings in a host of overlapping problems of our society that seldom fall readily into neatly separable categories. The web of interrelated aspects of the problem of environmental quality has many points of contact with the general problem of air pollution, which might itself be subdivided as:

- physical and chemical features of air pollution
  - chemical composition of pollutants
  - photochemistry and photocatalysis of pollutants
  - meteorological effects, mixing and deposition
- consequences of pollution in man, animals, and plants
  - disease induced by pollutants
  - long-term systemic poisoning
  - economic costs and physical damage
  - impact on the "quality of life"
- sources of pollutants
  - automobiles and other transportation systems
  - power production and heavy industry
  - municipal sources (including waste disposal)
- economic and legal aspects of pollution
  - efficacy of burning laws
  - enforcement and air quality standards
  - balance of costs and benefits of control

Air pollution clearly is a component of the larger topics of "structure of the urban environment" and "technology and economic development" as well as "environmental quality."

Among problem areas that might reasonably receive special attention are studies of the impact of particular developments in science or technology on society, and problems in which imaginative use of the scientific approach appears to offer an unusual opportunity to develop new insights or a path toward practical solutions. Since one of the important aspects of the program is collaboration between natural scientists and social scientists, problems with a substantial technological component would be particularly appropriate for study. Thus case studies of the social effects of implementing technologies and programs devoted to the development of new technology in explicit response to perceived social needs would both be particularly suitable.

A description of some of the research topics contained in preliminary informal proposals already received by the Foundation may indicate some specific topics on which full fledged proposals may be submitted.

Example 1: *Criminology and Nuclear Science.*—A university with a modest sized nuclear physics laboratory and a group studying criminology and forensic science proposes research on "application of nuclear science techniques to the characterization of physical evidence." They hope to carry out an exploratory study to learn whether charged particle scattering can be used analogously to the technique neutron activation in making precise identification of evidence, such as glues, hair, soils, cloth fibers, etc. The hope is that a whole new class of techniques for identification of evidence might be developed.

Example 2: *Systems Analysis of Urban Transporation.*—A major university with an interdisciplinary laboratory oriented toward applied research and computer development wishes to organize a detailed in-depth study of the effect of transportation services on the growth of a single urban area.

The project would involve urban planners, social workers, engineers, and natural and social scientists and would rely heavily on computer analysis and systems simulation techniques. The hope is that major improvements in approaches to urban planning would ensue, new techniques of analysis would be developed and a substantial body of baseline data would be gathered. The project would involve extensive cooperation with and some participation by public officials in the locality.

Example 3: Members of a newly instituted interdisciplinary group in a first-class institution wish to study the social aspects of environmental problems in conjunction with an environmental sciences group at the same institution. Such research problems require continued and effective collaboration between natural and social scientists.

It must be stressed that projects such as those described above may undergo considerable change in character or scope as the process of proposal refinement continues.

Question 2. In what way would the program encompass both basic and applied research, and roughly in what proportion? Would certain projects be devoted to basic and others to applied research? Or would single projects include elements of both basic and applied research? If the latter, would specific projects start in basic research and over a period of time shift to applied research?

Answer. Much of the work to be supported under this program will be basic research that could, in principle, have been supported before the recent broadening of the Foundation's scope. Estimates of the relative proportions of basic and applied research are, however, difficult to make. The distinction between basic and applied research that is often made is usually based either on the special viewpoint of the specific scientific discipline concerned or on the intent or motivation of the individual scientists. Thus "basic research" can be interpreted as "research basic to that field," and "applied research" may be either the application of that research seen as basic to the given field or research carried out with a particular practical and immediate objective in mind. All the research supported in this program will, to a greater or lesser extent, be motivated by practical concerns—the pressing problems of our society, but much of the work will undoubtedly be "basic" by the standards of some of the disciplines involved and "applied" from the standpoint of other disciplines. For example, a thorough examination of all aspects of air quality in a given airshed may involve some *basic* and *applied* engineering, *basic* atmospheric physics, some *applied* economics, some *basic* political science, some *applied* epidemiology, etc. Generally, the emphasis will be upon fundamental scientific research—the gathering of the underlying new knowledge necessary for the understanding and analysis of the problems of society—without making an artificial distinction between basic and applied areas. It can be expected that given projects will tend toward the "applied" as times goes on—in the sense that, if it becomes apparent that they do not promise to shed some light on a significant societal problem, they are unlikely to be continued.

Question 3. What role is envisioned for the social sciences in this program?

Answer· The social sciences will undoubtedly play a central role in much of the research supported under this program and the direct participation of social scientists will, in many cases, be an essential ingredient. One aspect of the program is the expectation that investigators in other disciplines can bring new skills, insight, and enthusiasm to bear in research on problems of society. However, it is clearly and explicitly recognized that the understanding of human society is the principal research goal of social scientists and that they have access to detailed factual information and an ever-broadening conceptual base that should form an integral part of that research. Problem analysis and proposed solutions based upon technological efficiency or managerial neatness are often incomplete due to failure properly to assess social impacts, conflicts with human values, basic human behaviorial traits, or practical political obstacles about which social scientists should be best able to provide helpful insights. Some projects may be multidisciplinary within the social sciences. (For example, a workmanlike and systematic analysis of alternative approaches to urban poverty requires at least the talents of sociologists, economists, and political scientists.) The aim of such research would, of course, be to analyze and compare available alternatives and develop new knowledge that bears directly upon matters of social policy, not to recommend, substantiate, or advocate specific programs of social action.

Question 4. What role is envisioned for engineering in this program?

Answer. Engineers should play a key role in research in many of the problem areas that will be included in this program. The goal of the engineer is to combine his scientific and engineering knowledge with an understanding of social and economic requirements in order to produce new goods and services that will meet the changing needs of society. The resolution of social stresses will, in many instances, depend directly on well-planned technological developments, practical device design, and a keen sense of social utility.

In addition, modern engineering now possesses powerful tools such as systems analysis, statistical decision theory, and computer simulation that promise to provide significant and largely unexploited new techniques for the study of society's problems.

Today's problems will require new kinds of engineering skills, and the research supported by this program should have a salutary effect on engineering education. Substantial numbers of committed and able younger faculty have joined the engineering schools in recent years, and are eager to contribute to solving the pressing problems of modern society.

Question 5. What role is envisioned for the professions (law, medicine, public and business administration, etc.)?

Answer. It is hoped that this program will provide a significant incentive for cooperative research between university scientists and professional school faculty, who have traditionally been somewhat aloof from their academic brethren. This participation is vital since the professional schools train practitioners in law, medicine, public administration, etc. who go on to play key roles in our society. Further, participation by professionals who are active in public life will also be encouraged, where appropriate.

Participation by lawyers is important since many problems are circumscribed by legal constraints and tangles of public procedure that may greatly complicate the alternative solutions to a given problem. Legal research and the lawyers' facility for dealing with a variety of broad and complex issues, and with the practice of resolving individual problems, will undoubtedly be of great value in many of the projects proposed under this program.

Medical doctors can be expected to make special contributions in dealing with social problems involving disease and environmental quality. Most participating M.D.'s will probably be faculty at university medical schools who join a research group as a part-time activity. In some cases, participation of medical people will be essential since many important public issues revolve about such questions as consumer safety, drug efficacy, and the health effects of various environmental contaminants.

Question 6. What, if any role, is envisioned for the humanities? If a role is anticipated, how would the program relate to, and coordinate with, the activities of the National Endowment for the Humanities?

Answer. This program is designed for the support of scientific research and thus the humanities cannot be expected to receive large-scale support. The most evident way in which humanists might be involved in some projects would be through consideration of such broad topics as "the quality of life" or as among the aspects of "human ecology." Useful insights from nonscientists will not be ignored due to doctrinaire rigidity, but the major emphasis must necessarily be on scientific analysis of the problems at hand. Such involvement of the humanities or of humanists as does arise will be coordinated with the National Endowment for the Humanities by the same procedure as described for other federal agencies in the response to question 7.

Question 7. What measures will be taken to coordinate this program with related activities of mission-oriented government agencies with responsibilities in areas such as water and air pollution, transportation, housing, etc., (both in the award of proposals and the administration of grants)?

Answer. Virtually every major problem of our society falls within the purview of one or more other Federal agencies, that may have either leading or subsidiary responsibilities in dealing with the problem at hand. In such cases, the Foundation will develop and maintain close relationships with that agency and will consult with it concerning work undertaken which impinges on that agency's assigned area of responsibility. Efforts will be made to coordinate research undertaken under the program with the needs and interests of the other agency.

It is anticipated that the principal mechanism for effecting this coordination will be the routing of appropriate proposals to cognizant agency officials for review and comment. In many cases officials in other agencies may be the most

knowledgeable reviewers we might find. Having agency officials participitate in the review process thus will fulfill two important functions. It will provide the Foundation with reviews from realistic, experienced professionals whose own work is necessarily multidisciplinary, and will keep the key officials with direct responsibility for work in areas related to the proposal, informed of the existence and interests of the proposer. Such a procedure allows peripheral involvement of other federal agencies without requiring formal commitments, unwieldy interagency panels, or joint management agreements or arrangements. This procedure will permit other federal agencies to regulate the extent of their own participation in particular areas depending on the depth of their interest, and will facilitate the free flow of information, at the program level, across interagency boundaries. Although no specific organizational or procedural commitments have yet been made, it is expected that Foundation program staff will participate freely in formal and informal interchanges with other agencies, particularly as regards final grant awards and dissemination of research results. An up-to-date description of all active projects will be maintained and made available, on request, to other federal agencies.

Although participation with other federal agencies in joint support of a given activity will not be ruled out, such multiple funding is expected to be relatively rare, arising primarily in support of conferences and preliminary studies or under circumstances in which another agency wishes to supplement Foundation support of an activity already in being. The primary intent is to support research in appropriate areas which other agencies are unable to provide effective stimulation whether because of limited mission relevancy, limitation of objectives, restrictive ground rules, inefficient contact or incomplete rapport with working scientists or for other practical reasons. As projects supported through this program reach fruition, the Foundation will hope to become an efficient coupling mechanism bringing other federal agencies in contact with the research results and with the scientists themselves. The success of such an endeavor depends strongly upon breadth of knowledge, tact, and professional competence of the Foundation's program staff.

Question 8. Why does NSF believe such a program can best be carried out by support of projects at universities? Has NSF considered foundations and other similar non-profit organizations?

Answer. There are several reasons why the principal emphasis in this program will be on support of research in universities.

The universities constitute the principal reservoir of the nation's high-grade scientific talent. It is essential that the best minds possible be engaged in considering society's alternatives and in developing the fundamental understanding that is needed for wise public choice. It is no accident that so many able people have chosen careers as university scholars. They are there because the university offers the most fruitful environment in which to think and work, and the special benefits associated with free and open inquiry. By focusing this program on universities, the Foundation is simply making explicit the recognition of this source of expertise that has been largely untapped for social program solving.

More than any other federal agency, the Foundation has evolved an intimate and mutually appreciative relationship with university researchers and with the total national effort in graduate education. Further, clear and direct lines of communication already exist between our program staff and university faculty members and administrative officers. The Foundation is thus already equipped, by structure and tradition, to bring a new program of this sort into being without distortion of institutional priorities. This is one of the principal reasons for establishing this specific program in the Foundation.

The problems of society, also, are long-term in character, and are unlikely to be susceptible to easy resolution. It is thus important that significant numbers of younger scientists and students at all levels of higher education be exposed to the nature of the probelms of the real world, and that many students develop a taste for interdisciplinary, problem-oriented research. On leaving the university they can then make immediate and constructive contributions to the resolution of our social ills. The research supported under this program will allow the involvement of graduate students and postdoctoral research associates who, it is hoped, will go on to be an important addition to the nation's pool of resourceful and committed scientists, and will be available to staff public agencies and private firms that are actively bringing about the implementation of constructive new programs.

Universities play a special role in society since, in principle, they provide a forum where ideas are analyzed on their own merits and the free search for truth is the controlling ethic. At the same time, the development of an understanding of problems of our society must be communicated openly and discussed freely, since the resolution of these problems will lie, in part, upon the existence of an informed electorate. Open publication and analysis of research results is a vital feature of the academic process, and forms a necessary element in the system of incentives and rewards to which university scientists respond. University researchers supported under this program will thus feel a special need to publish and discuss their results openly, and expose their conclusions to detailed and searching criticism by their colleagues.

There are strong indications that both faculty and students in our universities are eager to devote their talents to multidisciplinary research of the sort contemplated here. This program will provide a specific and identifiable locus for the constructive mobilization of such academic impulses toward "social relevance." The universities are now experiencing very severe stresses as they seek to accommodate themselves to a changing social environment that they, heretofore, have been relatively slow to recognize. This program will assist the universities in encouraging a reorientation of their research effort that many of the faculty and students desire and that is not adequately responded to by other federal agencies.

It must be stressed, however, that the nation's problems will by no means be entirely solved in the universities. While our academic institutions can make important contributions in broadening the base of knowledge and manpower, that are ill-equipped for important tasks such as engineering development, production, social implementation, and the organization and management of major social programs. Indeed, all these activities are the natural domain of other entities in our society. In particular, the federal laboratories may come to play a special role in the development and implementation stage of new programs, and the Foundation will cooperate where appropriate, with these efforts.

It is recognized also that a prototype for multidisciplinary research on specific problems already exists in the form of various nonprofit research laboratories, some of which are closely related to the university environment. Many of these organizations already have a substantial on-board competence in multidisciplinary research and have made significant contributions in such civilian areas as urban mass transport, aviation traffic control systems, and housing technology. Support of specific research projects in such nonprofit organizations will not be excluded under this program, but it is not anticipated initially that the Foundation under this program will serve as a founder or the principal supporter of such an institution.

Question 9. Would grantees be able to subcontract portions of their grant to non-academic organizations that possessed important interdisciplinary skills?

Answer. The subcontracting of major portions of grants to non-academic organizations will not normally be expected to play a major part in projects supported under this program. There may, however, be special instances in which the involvement of specific nonprofit or commercial concerns is necessary for adequate performance of the research, such as the construction of model or prototype devices, fabrication of special equipment, or performance of statistical or data gathering services. Such involvement will be closely monitored by Foundation staff and will be carried out according to procedures already well established for other substantive research programs.

Question 10. Would some grants be made directly to non-academic organizations, such as industrial research firms?

Answer. Proposals from commercial firms will not ordinarily be supported. Since the purpose of this program is to develop scientific knowledge that will have wide applicability and be freely available, it is unlikely that most industrial firms would be interested. Statutory restrictions, also, limit Foundation support of applied portions of the program to academic and nonprofit institutions, except in specific instances where the President directs otherwise. Exceptions will be considered in instances in which a specific task or service is to be contracted for, in a manner consistent with the operation of other Foundation programs. Intermediate situations, such as arrangements in which part of a research program is performed within a university under Foundation support while another part is performed outside in an industrial firm, will be considered on a case-by-case basis as necessary.

Question 11. Would this program impair in any way the quality of education at our universities by increasing the emphasis on research at the expense of teaching?

Answer. It is expected that this program will be compatible with, and an integral part of, the academic program of the institution, particularly at the graduate level. Thus there will often be related efforts that will provide for the participation or training of students in techniques appropriate to applying science to the problems of modern society. Further, studying the relation of science and technology to broad social imperatives may provide the appropriate mechanism for making the natural sciences and engineering more relevant to nonspecialists, stimulating both interest and involvement in what otherwise might simply be a part of the formal curriculum. Conversely, such programs may contribute to the developing of a healthy interest in public problems and a responsiveness to the public interest on the part of students specializing in natural science and engineering. It is thus anticipated that this new effort in research will have a directly beneficial influence on the teaching programs in colleges and universities.

New courses and seminars in areas corresponding to the anticipated research efforts already are springing up on many university campuses and it is expected that a major effort in the planning stages of these problem-oriented research projects will be devoted to seminars, conferences, and experimental courses designed to test the dimensions of faculty and student interest. It is hoped that broadening of the research involvement of the faculty will lead to fruitful and stimulating interchanges with students and faculty in other disciplines, and consequently, a marked *improvement* in university teaching.

Question 12. What does NSF expect this program to contribute which cannot be obtained from existing programs in NSF and other agencies?

Answer. Some aspects of the proposed program are touched upon by projects already supported by the Foundation and by other federal agencies. However, the existing Foundation program offices are organized along disciplinary lines, just as are the academic institutions. The disciplinary structure of the Foundation thus tends somewhat to inhibit support of multidisciplinary research. Numerous multidisciplinary programs have found a place within the Foundation under circumstances in which the disciplines were closely related, for example, multidisciplinary engineering projects are supported in the Engineering Systems program. But when the disciplines involved are quite far apart it has proven quite difficult to provide adequate review and support. Establishment of this program will provide a specific focus within the Foundation for research relevant to problems of society, with a clearly recognizable function and a staff particularly sensitive to the problems associated with doing multidisciplinary research. It thus will fill a significant gap in the present array of Foundation programs.

In addition, the establishment of this program will help to demonstrate the existence of a sensitive and responsive attitude, within the Federal Government, towards the special problems of universities and their long-range objectives of service to society. It would be unfortunate if the strongly expressed desires of university scientists to turn their efforts toward socially constructive research and teaching were not met by an appropriately designed Federal program.

An ancillary advantage to the Foundation will be the regular crossing of disciplinary boundaries within our own organization. In order for the program to draw effectively on the full range of talents represented on the Foundation staff it will be essential to establish communication and cooperation between elements of the staff with disparate professional backgrounds who would not normally come into contact. It is expected that suggestions and aid in the execution of the program will come from all levels and specialties represented on the staff, and from other major organizational subdivisions as well as Research. Significantly, increased internal coherence may very likely result.

Many programs in other agencies have begun important research efforts in socially relevant areas. However, the style of university research is often misunderstood and many mission agencies have found a close coupling with academic institutions quite difficult to achieve. Moreover, since our goal is fundamental research, we can afford to take a much longer-range view than can agencies that must be responsive to immediate end uses. In the course of developing this program, the Foundation will naturally make many contacts with programs within other agencies and develop an enhanced appreciation of their program objectives. An important side benefit will therefore be a growing ability

to serve as a communications link between university scientists and other federal agencies. The Foundation staff can then perform the vital task of bringing together agencies and researchers that possess a strong common interest.

Apart from these functions, the research itself should produce exciting new insights that will come to be increasingly important in the development of public policy and the realistic resolution of many of society's problems.

Question 13. What does NSF anticipate with regard to the future growth and development of this program?

Answer. The future growth and development of this program will depend in large measure on the degree to which its objectives are being met. It is quite conceivable that multidisciplinary research efforts will not flourish sufficiently in the university environment to make major expansion of this program desirable. It is also possible that the breadth of response anticipated from the academic community will not, in fact, materialize. Obvious hazards exist in mounting new programs that are not organized along the same lines as the universities, and these hazards must not be discounted. If the program cannot make reasonable progress toward its objectives it will be reduced or terminated.

It is expected, however, that the response will be strong and that once the scientific community becomes aware of the program there will be a healthy surge of promising and innovative proposals. The growth of the program must then be dependent upon the number of truly high quality proposals received. Indefinite growth is not anticipated, however, both since the multidisciplinary style of research will not appeal to all scientists and because the resources of the institutions also are limited.

As projects develop it can be anticipated that some may become very sizeable in conception or execution, or that a group of projects may gradually coalesce into a clearly definable effort directed toward a single goal. In such cases it may be appropriate to separate out such efforts for special programmatic treatment. Some projects may gradually tend in content toward a single discipline. Their support may then be manifestly more suited to one of the disciplinary programs, so that a transfer will be appropriate. Finally, many efforts will lead naturally to implementation within a given social framework. In these cases, transfer to support by the cognizant mission agency may be anticipated. All these processes will tend to limit the over-all growth of the program.

It must be stressed that this is a frankly experimental program and much will depend upon the rsponse of academic scientists and the development of an effective and experienced program staff within the Foundation. Until such experience is gained it will be difficult to forecast the future course of the program.

Question 14. What effect would the reduction of $4,000,000 recommended by the House Subcommittee have on the launching of the program?

Answer. The Principal effect of the budget reduction recommended by the House Subcommittee will be a diminution in the scale of the initial program. This reduction would probably limit the number of initial major grants to existing groups, while an attempt would probably be made to preserve most of the support intended for planning grants. This choice would be made because of the extreme importance of encouraging and initiating a considerable number of projects since not all can be expected to mature into productive groups. In consequence, less support would be available to strengthen ongoing activities that are ripe for expansion or for further support.

The recommended reduction would also make much more difficult the support of a significant amount of research in nonprofit, non-academic institutions, even though many have strong programs in related areas already in existence.

Despite the reduction in funds recommended by the House Subcommittee, no reduction in scope is anticipated, since the problems of society are urgent and attempts to stimulate appropriate, broadly-based research needed for their solution should not be narrowed due to temporary fiscal limitations.

Question 15. What effect will the House Subcommittee's recommended deferral of $3,300,000 for resurfacing the reflector at Arecibo have on progress in radio astronomy?

Answer. In 1967 the Foundation appointed an *ad hoc* panel to consider the proposals for major radio astronomy facilities. The group was chosen to bring together scientists and engineers who understand the problems of radio astronomy and its instruments, represent a wide variety of fields, and specifically could not themselves expect to benefit from their own recommendations. It is already two years since the panel recommended moving ahead with the Arecibo resurfacing as a first priority step toward improving radio astronomy instrumentation. The most serious effect of a delay of several years in getting on with the urgent needs

of radio astronomy will be to lower the effectiveness of the country's present radio astronomers for a period of time equivalent to between 5 and 10 percent of their normal working life. This could result in sufficient discouragement that the better people would start leaving the field and the better graduate students would fail to enter it. It is very hard to measure these considerations but they are nonetheless real.

Once the new surface is completed, a number of advances in radio and radar astronomy will follow. One of the important discoveries of the last few years is the existence of interstellar molecules, particularly water vapor, formaldehyde, ammonia and the hydroxyl radical. These basic combinations of atoms have a strong bearing on our understanding of the origin of life in the universe. Molecular radiations falling in the newly available region of the spectrum will be observed with unsurpassed sensitivity.

Another important use for the new surface is the study of radio sources. Something like a hundred thousand radio sources at short wavelengths are within the sensitivity range of the Arecibo reflector; polarization of these sources can be studied at these wavelengths, and this is not possible under the present wavelength limitations.

A delay will inevitably mean cost escalation. Estimates have already risen to $3.8 million since the original proposal was submitted.

New very large facilities for radio astronomy are now being built in Great Britain, the Netherlands, West Germany, and India, any one of which will exceed in size corresponding facilities now available here. Existing facilities in England, France, Italy, Australia, and Canada are larger than facilities other than Arecibo available to astronomers in the United States. The new surface will place the United States in a leading position at short wavelengths, enabling U.S. astronomers to take the lead on the problems mentioned above.

Question 16. Are there any other areas or projects in astronomy into which such funds could be more usefully put at this time?

Answer. In addition to those items already in the budget and authorized by the House Subcommittee, the Arecibo re-surfacing is the most urgent item in astronomy. Others which have been considered but postponed to future years are additional optical telescopes and auxiliary instrumentation, and the following radio astronomy instruments: a large (440-foot) steerable reflector enclosed in a radome, a "homology" principle steerable reflector, the completion of the Owens Valley (California Institute of Technology) array of reflectors, and the Very Large Array planned by the National Radio Astronomy Observatory. The new Arecibo surface is the outstanding major improvement in U.S. radio astronomy capability which can be done at the lowest cost and earliest completion date.

Question 17. Do you consider it healthy for the American scientific and educational enterprise for the Department of Defense to support basic research at universities or university-operated facilities?

Answer. We believe it to be healthy for both the American scientific and educational enterprise and the Department of Defense for the Department of Defense or any mission-oriented agency to support basic research at universities or university-operated facilities. The Department of Defense must maintain a representative set of ties to the best science and technology in the universities. The universities should be aware of the importance of the role that science and technology play in the defense of our country. In addition, the NSF support of basic research at universities should be of such a magnitude that changing emphasis of DOD support, as can be expected as both problems and technology evolve, will not threaten the vigor and the growth of American science.

Question 18. Has NSF assumption of support for projects previously funded by the Defense Department impaired the overall balance of its research support by reducing the limited funds available for other projects?

Answer. The concept of a balanced basic research program is a very difficult one to assess. Different areas of science are in different stages of evolution at any given time. As a minimum, balance means that in each field the very best people are working on what are deemed to be the most important problems with the best instrumentation currently available. The NSF feels that it must review balance on a truly national scale rather than on a narrow, intra-Foundation scale. Consequently, NSF assumption of support for such projects has helped to preserve overall balance on a national scale. Limited funds limit the rate of progress in all areas.

Question 19. What would be the consequences if NSF did not assume support of such projects?

Answer. NSF has not assumed support for all projects or programs formerly supported by the DOD. In the instances in which the Foundation has decided to continue support, a failure to do so by the Foundation would have resulted in a disastrous imbalance within the national scientific and graduate education enterprise. Our largest radio telescope (Arecibo) would have been retired from research in radio and radar astronomy. That instrument is not ready for retirement but rather is ready for a more precise surface in order to enhance further its potentialities, as proposed in our 1970 budget. Radio astronomy research would have almost ceased at three out of a total of only twelve universities with roughly comparable programs and capabilities. A program of research in nuclear astrophysics which is widely acknowledged as being the best in the world would have stopped. Such an effect would have had even wider repercussions within the particular institution, and indeed within the whole national enterprise, because the institution had other commitments to the general area of astrophysics through programs in optical and radio astronomy and theory, which have made it an international leader in this general research area. The loss of the nuclear component would have been a crippling blow. In the fields of nuclear and particle physics several of the nation's most competent groups would have been forced either to cease research or seek a new field; and programs involving some of our most versatile instruments either operating or under construction would have terminated. Finally, some of the world's finest superconductivity research, pointing in the direction of opening an entire new field of cryogenic technology, would have been severely hampered, if not halted altogether.

Question 20. What further demands for NSF support of DOD originated projects do you anticipate in the future? Please indicate both projects and dollar amounts, if possible.

Answer. In responding to a similar question from the House we estimated that we were supporting during fiscal year 1969, at a current annual rate of nearly $12 million, 19 major projects formerly sponsored by the DOD. Initiation of NSF support of these projects has ranged over the period of time since 1965. Proposals from these projects must compete with all other proposals, and we must be continuously aware of the risk of underfunding individual projects when the availability of funding is limited and the competition is so keen.

DOD continues to support a large number of excellent university research projects and facilities whose caliber is such that their continued productivity is of extreme importance to the health of the American scientific and educational enterprise. If that DOD support were to falter by any significant amount, the Foundation would have to give very serious, and almost certainly favorable, consideration to the question of ensuring continuity of support and perhaps even improving or expanding the capabilities of certain programs in the best interests of American science. We are not at this time negotiating with the DOD regarding future NSF support for any of these major enterprises. However, in view of recent history it would not be surprising if one or more such problems did arise once the fiscal year 1970 appropriations are known.

In addition to these major projects, many investigators, whose support by other agencies had been terminated as a result of the shift in agency programs, have submitted to NSF research proposals of such high quality that they competed successfully with other proposals. Many of these investigators have changed the direction of their work prior to submitting a proposal to the Foundation, and the resulting pressure on the Foundation's resources cannot be related directly to actions by other agencies. However, a number of smaller projects for which NSF funding totaled $3,750,000 in fiscal year 1969 can be identified as having, within the last few years, been sponsored by other agencies. Additional support required for projects for which the Foundation may assume support in fiscal year 1970 is estimated to be about $3 million.

Question 21. Do you anticipate similar demands in the future for support of research projects currently supported by other agencies, such as NASA and AEC?

Answer. It is an inherent aspect of our present system of multiple agency, Federal support of research at universities that the pattern of support will be continuously changing as the mission-oriented agencies re-evaluate their problems and reorient their programs to concentrate their resources in areas which they believe to be most relevant to their missions. Consequently, the Foundation will always be receiving proposals for continuation of research activities whose prior support has been terminated by a mission-oriented agency as a result of a judgment based solely on mission relevance rather than scientific merit. The National Science Foundation cannot ignore such proposals because their scientific merit may be very high indeed. In addition, under present circumstances

level funding means less research, and we receive proposals to augment mission-oriented support. We must receive and judge these on their merit. We also feel that in a period of tight budgets mission-oriented agencies tend to narrow their definition of relevance, and that such action further increases the flow of proposals to the Foundation. We regard the AEC support situation as being quite stable generally, but we have recently been informed of AEC intent to allow 25 research grants in chemistry, involving a total annual rate of activity of approximately $400,000, to expire. There is also some cause for concern that some major AEC facilities may be under utilized. Similarly, the diminution of the NASA University Grants Program, as well as the decrease of the NASA fellowship program have been matters of grave concern to us.

In response to an earlier but similar question from the House we noted that while we can have no final information on the details of other agency programs in fiscal year 1970 until after action is complete on their appropriation requests, an estimate of the additional pressure of high quality proposals resulting from shifts of emphasis in other agencies, including DOD, NASA, and AEC, is given in the following table:

[Dollar amounts in thousands]

Field of science	Number	Amount
Mathematics		
Physics	10	$900
Chemistry	10	450
Biology		
Astronomy	10	900
Atmospheric sciences		
Oceanography		
Earth sciences		
Engineering	15	600
Social sciences	3	50
Total	48	2,900

Question 22. What decision-making structure and criteria are involved in determinations by NSF to support projects previously supported by other agencies such as DOD?

Answer. Applications for the support of projects previously supported by another agency are considered in competition with all other applications through the usual Foundation internal and external review process. In addition, projects large enough to cause a significant perturbation of the Foundation's support of a field are the subject of explicit discussion between high level officials of the Foundation and those of the other agency concerned. Representatives of OST and the Bureau of the Budget are sometimes invited to these discussions in order to insure that the implications for subsequent NSF budget submissions are fully understood and anticipated in those quarters. Such projects are also reviewed individually by the Director and, as appropriate, by the National Science Board. At all levels of review, the evaluations are based on the importance to the advancement of science of continued support of the particular project concerned. This competitive evaluation takes into account the real alternatives and is made in the light of the competition of other projects, large and small, for the limited budgetary resources.

Question 23. What will be the effect of the House Subcommittee's recommended deferral of $2,000,000 for construction of another oceanographic research vessel?

Answer. Deferral of $2,000,000 for construction of an intermediate size research vessel will mean that no Federal monies will be available in FY 1970 for carrying forward a much needed replacement program for the university-private institution oceanographic fleet. This program of replacement is well behind schedule already owing to repeated deferrals of funding plans by both NSF and the Navy.

Most basic research in the marine sciences is done by the academic and closely related private research institutions of this Nation as is the training of future practitioners of marine science and industry. Regardless of how the Federal structure may be reorganized to support marine science in the coming years, these institutions will need to continue operating their collective fleet of ships in order to carry out these two functions on which our national program depends. The condition of this fleet must, therefore, be considered in all future planning related to this sector of the oceanographic community.

In Fiscal Year 1970, 17 institutions now supported by the Foundation will operate 33 research ships ranging in length from 50 feet to 246 feet (see attached list). Fourteen of the 33 ships have been constructed since 1960. The remaining 19 range in age from 17 to 45 years; all but one are 20 or more years old and 14 are 25 or more years old. The Foundation and the Office of Naval Research are currently considering plans for the construction of replacements for all 19 of these ships. Such replacements are required if the university-private institution fleet is merely to hold its own in size and support its current level of activity. If any expansion of effort is to be expected by these institutions, either in research or training of manpower for marine activities, additions to this fleet must be also considered during the same time period.

SOURCES OF VESSEL CONSTRUCTION OR CONVERSION SUPPORT

Institution	Vessel	Length in feet	Year built	Year converted	Amount (millions)
University of Alaska	Acona	80	1961 Navy		
University of California	Agassiz	180	1944	1961 and 1968 NSF	$0.33
	Alpha Helix [1]	133	1965 NSF		1.54
	Argo	213	1944	1960	
	Melville	246	1969 Navy		
	Oconostota	102	1944	1962	
	Scripps	95	1965		
	Washington	211	1965 Navy		
Columbia University	Conrad	209	1962 Navy		
	Vema	202	1923	1953 and 1968 NSF	.40
Duke University	Eastward	118	1964 NSF		1.14
University of Georgia	Kit Jones	65	1938	1959 NSF	.02
University of Hawaii	Teritu [1]	90	1952	1964 NSF	.57
	Mahi	186	1944	1968 (Leased vessel)	
Johns Hopkins University	Warfield	106	1967 NSF		1.57
University of Miami	Gerda	75	1949	(Acquired in 1954)	
	Pillsbury	177	1943	1964 NSF	.85
University of Michigan	Inland Seas	114	1943	1961 NSF	.15
	Mysis	50	1963 NSF		.09
Nova University	Gulfstream	54	1963	1967 NSF	.08
Oregon State University	Cayuse	80	1968 NSF and other		.17
	Yaquina	180	1944	1964 NSF	.77
University of Rhode Island	Trident	180	1944	1962 Navy	
University of Southern California.	Velero IV	110	1948		
Stanford	Te Vega [2]	134	1930	1962 NSF	.70
Texas A. & M	Alaminos	180	1945	1963 NSF	.98
University of Washington	Hoh	65	1943	1963 NSF	.07
	Onar	65	1943 (Circa)	1962 Navy	
	Thompson	211	1965 Navy		
WHOI	Agor-15	246	1969 or 1970, Navy		
	Atlantis II	210	1962 NSF		5.0
	Chain	213	1944	1959 Navy	
	Crawford [1]	125	1927	1956	
	Gosnold	99	1941	1962	
Total					14.43

[1] Temporarily out of service because of Foundation expenditure ceiling.
[2] Being replaced with smaller vessel.

Question 24. Is it possible to make fuller utilization of the existing fleet of oceanographic research vessels through cooperative sharing of vessels by participating research groups?

Answer. This fleet is already over-utilized and not only needs updating with newly constructed replacement vessels but additional new vessels as well. The 33 ships listed in the foregoing attachment currently serve a community of approximately 3,000 individuals within the institutions which operate them. This community is comprised of approximately 1,000 research staff, 1,150 graduate stu-

dents and 850 technicians. In addition, approximately 950 research and graduate student personnel from other institutions utilize these research platforms in any given year. (Two of the 33 ships, *Eastward* and *Alpha Helix*, are operated as "national facilities" primarily for users from other institutions.) To serve a group of this size, these ships must be heavily scheduled. The number of days utilized per year varies as a function of several factors. For instance, the smaller ships are not able to operate under severe weather conditions and therefore in some geographical regions may log only 180 sea days per year. Larger ships used for long-range cruises may operate as much as 320 days per year. The material condition of any ship will affect the utilization rate since the time required for maintenance and emergency repairs increases with age. Given the mix of sizes and the preponderance of old ships in the academic fleet, the average utilization rate of nearly 250 days per year per ship represents a remarkably high usage level.

With increasing numbers of institutions developing programs in the marine sciences, the need for ship time is increasing at non-vessel-operating institutions. Some of these institutions are already seeking to become vessel operators on their own. Aside from the obvious consideration of limitations imposed by lack of funds for construction of new vessels and stringent budgets for operating the existing fleet, it probably would be prudent not to allow much further increase in the number of individual vessel-operating institutions. Instead, these institutions should be encouraged to form "user groups" which would either operate their own pool ships or arrange with present vessel-operating institutions to operate pool ships as a service function. The latter alternative would permit more efficient utilization of shore facilities and supporting staff.

Question 25. What steps has NSF taken, or does it intend to take, to assure the most effective utilization of the existing fleet?

Answer. Through its system of "block support" of ship operations NSF has evolved a system of close review of the operations of the academic fleet. The Foundation's support of ship operations began with the inclusion of funds for this purpose in individual research grants. When vessels were small and costs were comparatively low this piecemeal approach to funding was possible if not entirely satisfactory. As early as 1959, however, research vessel operators were urging some form of block funding for at least half the annual costs of operation of the fleet in order to make possible efficient and orderly planning of both operating and maintenance schedules. In recognition of this problem the Foundation began in the early 1960's to make some grants solely for support of the operation of ships separate and distinct from research support. This was termed "block support" since each such grant provided a block of funds toward the total cost of operating one or several vessels at a given institution. Grants of this type became Foundation policy for all ship operations support in FY 1966. In addition to aiding institutions in planning their annual ship operating schedules, this block support program has made it possible for the Foundation to monitor its support much more carefully. Uniform requirements have been established for preparation of proposals in sufficient detail to provide both current and projected costs and reports on past use and future plans for each individual vessel in the fleet. Sources of funding, both current and projected, are included so that the Foundation may determine yearly its role with respect to other agencies in this support effort. Decisions concerning annual support levels can therefore be made with a solid background of information concerning vessel management, maintenance, scheduling and comparative costs. Information is required concerning intensity and effectiveness of use of each vessel (see attached Table entitled "Vessel Usage—1967") and lists of users from other institutions are obtained.

A Ship Operations Review Panel consisting of two NSF staff members and four outside consultants visit approximately one third of the vessel operating institutions each year and hold an annual meeting to review all ship operations renewal proposals. The intent of this entire review process is to assure that the fleet is used effectively and operated efficiently. Comparative operating costs between institutions are watched closely, for example, as one means of determining efficiency. The attached Table entitled "Sample Operating Budgets for Three Sizes of Vessels (FY 1968 Budgets)" illustrates the kind of information obtained as a basis for such comparative evaluations.

30-553—69——6

VESSEL USAGE, 1967

[Based on 9 vessels operated by 4 major oceanographic institutions]

Institution/vessel (maximum scientific complement)	Total days out of home port	Working days at sea	Number of cruises	Man-working days at sea
Columbia University—Lamont-Doherty Geological Observatory:				
Conrad (15)	348	308	1	5,368
Vema (17)	335	296	1	4,412
University of Miami—Institute of Marine Sciences:				
Pillsbury (13)	245	236	10	2,596
Gerda (8)	215	199	26	1,055
Oregon State University: Yaquina (19)	250	207	44	2,064
Woods Hole Oceanographic Institution:				
Atlantis II (24)	286	267	9	2,978
Chain (26)	231	218	13	3,655
Crawford [1] (7)	187	183	13	875
Gosnold (7)	223	217	14	572

[1] Now out of service because of expenditure ceiling.

SAMPLE OPERATING BUDGETS FOR 3 SIZES OF VESSELS (FISCAL YEAR 1968 BUDGETS)

	80-foot vessel	180-foot vessel	213-foot vessel
A. Salaries and wages (crew, technicians, marine operations staff)	$141,300	$212,000	$391,000
B. Repair, overhaul, and alterations:			
Maintenance, repair and overhaul	17,500	84,000	125,000
Capital equipment and improvements	[1] 0	43,000	8,000
Subtotal	17,500	127,000	133,000
C. Other:			
Fuel	8,600	25,000	50,000
Steward's supplies	1,400	29,000	7,000
Spares and stores	[1] 0	20,000	30,000
Fees, insurance, and travel	5,000	34,000	11,000
Distributed charges, miscellaneous expenses and indirect costs	46,000	49,000	169,000
Subtotal	55,900	157,000	267,000
Total	214,700	496,000	791,000

[1] Vessel new. These items will begin to appear in next year's budget.

Question 26. If Congress follows the recommendations of the Commission on Marine Science, Engineering and Resources and establishes a NASA-like agency for the ocean environment, what should be the relationship of such an agency to NSF's program for constructing oceanographic research vessels; and does the possibility of establishing such an agency provide grounds for deferring construction of the proposed vessel?

Answer. The Commission report leaves open to question the number of existing oceanographic institutions which will be converted to so-called "University-National Laboratories." Note the following quotations from the report pertaining to this point:

Page 5.—"The Commission proposes that a small group of institutions, including the present leaders in ocean research, be designated by the Federal Government as University-National Laboratories and be equipped to undertake major marine science tasks of a global or regional nature."

Page 27.—"The number, size, and scope of such major centers depend on the priorities ultimately assigned to various elements of the national ocean effort, the availability of funds in competition with other needs, the willingness of major universities to commit themselves to such programs, and other factors. The laboratories would include, but not be restricted to, the presently acknowledged leaders. Certainly, University-National Laboratories will be needed on the Atlantic, Pacific, and Gulf coasts, the Great Lakes, in the Arctic, and in the mid-Pacific."

Page 205.—"A basic need is to provide adequate institutional support to meet basic operating expenses of the proposed University-National Laboratories, which will have a key role in research and exploration. The Commission has not at-

tempted to specify how many laboratories should be brought within this system; for purposes of the funding estimate, a dozen such laboratories have been assumed."

From this it may be concluded that not all seventeen vessel-operating intitutions now supported by NSF would be included under the proposed umbrella-type support for the University-National Laboratories. Whether the facility needs of other university oceanographic laboratories would be considered by NOAA in some other fashion is also not clear. Certainly until an agency such as NOAA comes into existence, all of the university and private research institute laboratories will continue to look to NSF and the Navy to fund fleet replacements and additions. Our answer to question #23 attempted to convey the urgency of need for funding replacement vessels for the academic fleet *now* regardless of what agency funds operations, replacements and additions in the future. Even after such a new agency is established the needs of some laboratories may still be the responsibility of NSF. Thus there appear to be no grounds for deferring or discontinuing the NSF program for support of oceanographic facilities.

Question 27. What will be the effect of House Subcommittee's reduction of $245,000 for National Register activities?

Answer. The prime result of the House Subcommittee's action, in regard to the National Register program for FY 1970 will be an effect on the program for the Registration of Engineers, revising its budget downward from $315,000 to $100,000. The remainder of the reduction will be absorbed within the program for the Registration of Scientists, making necessary reductions in the contracts to cooperating scientific societies and in the services expected of them.

The important change that will result from the Subcommittee's reduction is cancellation of plans to expand the coverage and sample for the registration of engineers. It is estimated that there are at present nearly 1.1 million engineers in the United States. The 1969 registration of engineers is based on a sample of 100,000 names drawn from an unduplicated list of approximately 400,000 engineers belonging to 19 professional organizations. In asking for $315,000 for FY 1970 for the Regstration of Engineers, NSF had expected to finance expansion of the unduplicated list of engineers to about 600,000 names of members belonging to about 40 societies. It was also planned to canvas a sample of approximately 200,000 names from the expanded list. With these expansion plans cancelled, our budget as revised for FY 1970 will only permit the next registration of engineers to be on the same scale as the 1969 sample registration.

Failure to expand the coverage and sample of the Registration of Engineers means that the analysis of engineering manpower will continue to be restricted. The present sample is too limited—both in coverage of societies and in size of sample—for many problems with which the country will be increasingly concerned in the area of engineering manpower. Indeed, the expansion planned for the next registration was only a first step for improving engineering manpower coverage. In subsequent registrations it was planned to embrace more societies in the registration and to include engineers who are not members of professional organizations.

Question 28. In view of recent developments related to the State Science Policy Program, do you believe the Foundation could make effective use of an additional increase beyond the $150,000 increase recommended by the House Subcommittee? If so, how much additional funds could be utilized effectively?

Answer. Because the program is essentially new and in still somewhat of an experimental stage, it will have to grow relatively slowly to allow for an assessment of presently sponsored efforts. Thus, the $300,000 level for the program, as recommended by the House Subcommittee, would be an appropriate amount for continued and effective growth in the program for FY 1970. Beyond FY 1970 program growth will depend on: (1) the availability of qualified investigators; (2) evaluation of the effectiveness and utility of presently supported activities in the program; and (3) the extent to which governments at the state and local levels feel that the program contributes to their own efforts.

Question 29. Do you believe it would be constructive for Congress to conduct hearings this year on the NSB recommendations, and related issues, regarding graduate education in the sciences?

Answer. During the past year many important studies, in addition to that of the National Science Board, have been reported. These studies serve to document a rapidly growing concern across the Nation over the appropriate Federal role in the financial support of higher education—and especially of its most expensive component, graduate education—and the most effective means for making

this support available to our colleges and universities. These studies have been conducted both within the Federal Government and by private organizations. Together they represent the best thinking of the most experienced and knowledgeable individuals in this important area of public policy. They share several common conclusions:

The next decade will present an unprecedented challenge to our institutions of higher education in terms of the numbers of students, both undergraduate and graduate, who will seek the opportunity for advanced training both in the sciences and engineering and in all other fields.

The cost of providing this opportunity will escalate at an even more rapid pace. This trend cannot be avoided if America is to retain its long-established goal of enabling each citizen to pursue an education to the limits of his ability and interests.

While important financial support of higher education will continue to be provided by State and local governments and by private sources, the substantial and growing participation of the Federal Government is absolutely essential to meeting the needs of the 1970's.

At the same time, these studies differ in their emphasis and in their priorities. The NSB report is unique in that it is addressed to graduate education, that is, education at the frontiers of knowledge, an experience basic to those who must lead our Nation's continued progress on scientific, technological, and social fronts. The polarity among these reports, although they are really complementary in that they emphasize two separate aspects of the common problem, can be summarized by the two types of mechanisms, proposed for Federal use:

The first is the expanded use of individual student stipends, together with "cost of education" allowances to institutions, to provide for equality of educational opportunity among all groups of citizens.

The second is the expanded use of unrestricted grants to the colleges and universities themselves to retain for these institutions their autonomy to maintain themselves, to provide for the continuity of their faculties and essential services, and to permit them the flexibility of planning their programs and their directions for the future.

I believe very strongly that it is both important and urgent for the Congress to examine these matters, to attempt to resolve possible points of difference, and to formulate a public policy—particularly as it affects the Federal role with respect to graduate education—that will serve the Nation during the years ahead. I would certainly endorse hearings by the Congress this year on this vital subject.

Question 30. How would a possible bill, based on the NSB recommendations, relate to the Miller-Harris bills (H.R. 35, amended by H.R. 11542, and S. 1563) which would establish a National Institutional Grants Program?

Answer. The NSB report has recommended the adoption of six types of grant instruments to be used for the Federal support of graduate education in the sciences and engineering and for possible extension to the support of graduate education in all disciplines. These grant instruments are:

Institutional Sustaining Grants identified with faculty salaries, a relatively small number of student stipends for flexible disposition by the institution, and general institutional expenditures, currently construed as the "indirect costs" of research grants and contracts, related to graduate education.

Departmental Sustaining Grants to provide for graduate student stipends, the research needs of young investigators, and the operating expenditures of disciplinary departments and programs.

Developmental Grants to assist institutions in the formation, expansion, or improvement of their graduate programs.

Graduate Facilities Grants to assist in providing the general and specialized facilities and libraries needed for graduate education.

Graduate Fellowships awarded on a competitive basis to assist in establishing and maintaining quality standards.

Research Project Grants to assist with the direct expenditures for academic research that are not included in the five mechanisms above.

These proposed grant instruments are not new, but their definition implies a fundamental redistribution of the institutional expenditures that have been identified with each during recent decades. The NSB recommendations thus represent a basic restructuring of the Federal grant mechanisms, a step that is believed to be necessary to ensure the integrity of the institutions themselves and a sound relationship to the Federal Government.

The pending legislation is of a different character. These bills propose the establishment of an institutional grant instrument that would provide supplemental funds over and above that provided by current Federal programs. These grants would be responsive to both the undergraduate and graduate elements of colleges and universities. There is, however, no fundamental contradiction between this type of grant and the Institutional Sustaining Grant, recommended by the National Science Board. Both would represent important unrestricted funding for use by the college or university; both contemplate the use of a formula involving factors that are, in fact correlates of institutional quality; and both could be extended to encompass the arts and humanities, as well as the sciences and engineering.

Question 31. Does the NSF plan to ask the Administration to submit a bill, based on the NSB recommendations?

Answer. In his transmittal message to the Congress, dated February 18, 1969, which accompanied the submission of the NSB report, President Nixon stated:

"Graduate education is a critically important element in the educational process and one which is entering a particularly difficult period * * * Thus it is most important that colleges and universities, state and local authorities and the interested branches of the Federal Government all re-examine their role with respect to graduate education * * * I have recently instructed the Secretary of Health, Education, and Welfare to establish an interdepartmental study group to make an overall review of the Federal role in education, including higher education. The Report of the National Science Board will provide a useful resource for that review."

Pending the completion of this review it would be premature to ask the Administration to draft proposed legislation.

Question 32. How is NSF communicating its authority to support applied research at universities to the scientific community?

Answer. Under its new legislation the Foundation is authorized to support "scientific research, including applied research at academic and other nonprofit institutions." Under this new authority it is planned, beginning in fiscal year 1970, to broaden the competition for research support to include applied research.

When the booklet, *Grants for Scientific Research* is re-issued this summer, the words "scientific research" will be substituted for "basic research" throughout. It is not planned, however, to broaden the eligibility requirements which at present restrict the bulk of funds to academic and academically related nonprofit institutions.

Question 33. What kind of response is anticipated?

Answer. We do not expect our new authority to support "scientific research, including applied research, at academic and other nonprofit institutions" to result in a flood of new and expanded proposals. One reason is that many types of applied research cannot effectively be carried out as part of an academic program, but are more suited to an industrial type of approach. Another reason is that we have always used a broad definition of basis research. For example, in engineering we use the concept basic *for engineering*, rather than basic from the point of view of, say, a theoretical physicist.

Likewise, in every field, we have used the concept "*basic to that field*," and have avoided imposing an abstract, external criterion of scientific "purity." This is true in the social sciences, for example, where many of the problems studied have been based on real societal situations.

The line between basic and applied research is a very difficult one to draw sharply. One can say that a piece of scientific research is more basic or more applied, but there is no general rule which can be used which neatly separates all research projects into two groups. In fact, a given project may be considered that we have always used a broad definition of basic research. For example, in understanding nature, and applied by another, who is primarily concerned with possible applications.

Proposals received will be handled by our existing organization. However, some expansion of staff will be necessary because of the greater coordination and follow-up efforts required for research of a more applied nature. Most proposals are expected to lie within a single discipline, and may result from prior basic research. For example, an atmospheric sciences group may propose an applied research project to study the distribution of sulfur dioxide pollutant as a function of micro- and mesoscale atmospheric phenomena in an urban area. Such a proposal would be assigned for review to the Program Director for Meteorology in the Atmospheric Sciences Section of the Environmental Sciences Division. In

the review process, both its merit as a scientific program and its possible significance for solving our practical air pollution problems would be considered. Where appropriate, our Program Director would discuss the proposal with other Federal agencies having a mission responsibility related to the proposal.

Question 34. What effects will such support have on NSF's support of basic research in universities?

Answer. It is planned to support applied research through incremental funding rather than by reducing support of basic science. The Foundation will give preference to proposals for research activities which constitute an integral part of the normal academic program of the institution. Applied research is a valid part of the research experience of graduate students in many disciplines. Perhaps the most important aspect of our move to broaden the general competition for research support to include applied research lies in the fact that universities can now plan their research programs without having to cut off the more applied aspects in order to fit NSF's authority. Thus, our span of authority now more nearly coincides with the span of research activities which a university should undertake as part of its graduate program.

Question 35. (a) What steps is NSF taking to prepare itself to respond effectively to future White House assignments to support national applied research programs relevant to social problems or goals? (b) Is expanded planning activity in this area advisable at this time?

Answer. (a) Several steps now being taken by NSF will help prepare for future presidental assignments. In the applied research area, these include:

(1) Broadening the competition for research support to include applied research at academic and closely related nonprofit institutions, beginning in fiscal year 1970, as discussed in questions 32, 33, and 34 above.

(2) Studies aimed at identifying specific areas for programmatic support to be included in fiscal year 1971 and later budgets.

It should be noted that the Foundation has already had substantial experience in the support of applied research. As part of our Weather Modification Program, applied research has been supported since 1958 under the special legislative authority which was repealed in 1968. Research under the Sea Grant Program is almost entirely applied research in the marine resources area. Other areas in which the Foundation has supported applied research include: research on storage and retrieval of scientific information, and research related to development of a national science policy.

Also important in this connection is the new Interdisciplinary Program of Research Relevant to Problems of our Society, for which funds have been requested in the Foundation's fiscal year 1970 budget (see questions 1–14 above). This multi-disciplinary program could have been initiated under our previous limitation to basic research, but a more flexible program with enhanced scope is possible under the new authority.

(b) Expanded planning activity is not required in connection with possible presidential assignments. The Foundation plans to take some programmatic initiatives on its own authority in selected areas of importance to society beginning in fiscal year 1971. A presidential assignment would remove the limitation to nonprofit institutions for research in the assigned area. Otherwise, program management would be the same as for NSF-generated programmatic initiatives.

Question 36. If so, are additional funds required to carry out such planning activity?

Answer. As indicated above, it is not felt that added planning activity is necessary for this purpose in fiscal year 1970. What is essential is experience in managing applied research programs, and this will be acquired as we take the steps outlined in the answer to question 35.

Question 37. If the Senate were to pass S. 1856. which provides NSF with greater flexibility in the use of its funds, does the Foundation currently intend to alter in any way the allocation of funds among programs as set forth in S. 1857?

Answer. The Foundation does not presently plan to change the proposed program allocations contained in S. 1857 if the full amount authorized is appropriated. However, an important advantage of the flexibility provided by S. 1856 is that it permits the Foundation to continually evaluate research, science education, and institutional science needs and to adjust program allocations to meet changing conditions and priorities.

It has been the policy of the Foundation to conform, in general, to the program plans as presented to the Congress in the budgetary process. In cases where circumstances have dictated a major change in the program structure or

a reallocation of funds to programs or projects that were not included in the budget, such action has been discussed with the appropriate Congressional committees before such action has been taken. For example, the Foundation recently discussed with the Congressional Committees the need to provide for the construction of a prefabricated hangar for research aircraft operated by the Foundation-sponsored National Center for Atmospheric Research. Also, in the fairly recent past, the Foundation discussed in some detail with the appropriate congressional committees,a project proposal which involved the joint support by the National Science Foundation and by the Ford Foundation of a 150-inch optical telescope for the Cerro Tololo Inter-American Observatory. After obtaining committee concurrence, the Foundation provided an initial increment of funding and included requests for the remainder of its share of the project costs in subsequent budget submissions. This procedure of conferring with the various interested Congressional committees would be continued if the Congress were to enact the broader authority contained in S. 1856.

Question 38. If such alterations were to be made what circumstances would obtain leading to them?

Answer. FY 1970 will be the first year that the National Science Foundation has had both an Authorization and an Appropriation. At the moment, the principal reason for altering the distribution proposed in the budget would be the priority requirements of the Foundation programs under the conditions of possible appropriations which are substantially less than the authorization. A significant part of the total funds made available to the Foundation in any given year represents relatively firm commitments which would have to be substantially funded in the amounts budgeted regardless of the amount of the appropriation.

For example, the Foundation has a large investment in physical facilities at the National Research Centers. The Centers serve broad groups of scientists located in a relatively large number of universities as well as those employed directly by the Centers. Generally the National Research Centers are afforded a rather high priority in funding in order that they can utilize the costly investment in equipment effectively to best serve the needs of the scientific community.

Similarly, there are other NSF program areas where there is a definite need for continued support. Among these are certain continuing research projects, the Antarctic Research program, the Ocean Sediment Coring program and other national research programs such as these. In addition continued support is needed for continuation grants for the University Science Development program where substantial investments have already been made from both National Science Foundation funds and university funds. It would be detrimental to the interest of the university not to meet our commitments for continued support as necessary in these areas.

In another context, it is evident that the operating costs of the National Science Foundation which provide for the salaries of permanent employees and consultants and travel costs of these employees plus all necessary expenses such as purchases and equipment, supplies, computer rentals, etc., must be funded substantially as budgeted regardless of the total amount of the appropriation.

Question 39. Could such alterations also be made effectively under S. 1857 through appropriate consultation with Congress when necessary?

Answer. Although S. 1857 is generally more restrictive legislation than S. 1856, the provisions of Sec. 3 would provide a mechanism for adjusting programs after consultation with appropriate committees of Congress. The amount by which the Foundation could adjust the funding of any program of the Foundation is limited by S. 1857 to not more than 5 percent in excess of the amount actually authorized for that particular program as specified in the authorization.

Question 40. Is it desirable for Congress to determine priorities by allocating funds among broad program categories as it does in S. 1857? Is this not one of the major purposes of the authorization process?

Answer. The Foundation regards as a major purpose of the authorization process the full presentation of its programs for consideration by the Congress. Since the authorization is an annual process, the Congress can work its will by a variety of mechanisms other than by authorization on a line item basis. The committee reports which accompany a general authorization such as S. 1856 can be effective as a mechanism for expressing Congressional intent as to various priorities of programs. The Foundation can then be held accountable by the committee for its performance within the constraints expressed in the committee reports. This mechanism has been in existence in the appropriation process since

the beginning of the National Science Foundation and might thus continue to serve the interests of the authorization committees.

Question 41. What impact would Section IV have on the availability of funding for NSF's programs in the future?

Answer. Section IV of S. 1857 would have the effect of limiting the accumulation of authorizations in amounts substantially in excess of the amounts appropriated over a three year period. The application of this section would not adversely affect the future availability of funding for Foundation programs, since there will presumably be an annual authorization at least equal to the amount of an appropriation.

Question 42. A recent report of the New York Academy of Sciences entitled "The Crisis Facing American Science" recommends the establishment of "guidelines for the annual growth rate of federal spending on scientific research," and asserts that a rate of 15 to 20 percent per year is reasonable. Do you believe such guidelines are desirable? If so, do you believe the rate of 15 to 20 percent is appropriate?

Answer. A guideline is desirable for several reasons: it provides a rationale for Federal research support; this rationale can be examined by all pertinent groups; on the basis of such reviews a generally acceptable guideline may be developed which can then be used as the basis for Federal funding of research; if the funding pattern adheres to such guidelines long-range national and institutional planning can be carried out more effectively.

In order to establsh a guideline for growth rates of national funding of scientific research, one has to face inevitably first the question of how much research should be supported in any given year. This question is not easily susceptible to quantitative analysis. However, it seems valid to assume that national research funding patterns established during periods which did not include unusual financial national obligations such as those due to the Vietnamese war, represent a national determination of the relative amount of GNP which should generally be allocated to research. This is the case because our national utilization of GNP is the product of a complex and multiple system of checks and balances with the end result representing a national consensus of funding priorities. Thus, it seems valid to assume that the 1966–67 levels of national or Federal funding of research are representative products of this complex national allocation process.

Having established this base, one can then deal with the question of future growth rates. Studies and available statistical data have shown the cost of research to increase in recent years approximately 7 percent per year due to inflationary factors and factors related to the increasing complexity of science and technology. Thus, to maintain even a constant level of scientific research activity a 7 percent annual growth in funding is required. In the case of academic research, one has to add another factor proportional to the expected growth in the number of graduate students. This is the case because academic research performs a dual function of enlarging our basic knowledge pool and at the same time provides training for our future scientists and engineers. Thus research activity is required in universities to provide research training for graduate students and to maintain the faculty's knowledge at the forefront of science. On this basis the magnitude of academic research activities should be proportional to the enrolled number of graduate students since this represents an index of both students and faculty (assuming a constant student to faculty ratio). Graduate student enrollments are increasing at an annual rate of approximately 9 percent. Consequently, if one wants to maintain the level of academic research activity on a basis of constant proportionality to the graduate student body, both of the above factors have to be taken into consideration thus indicating an overall 16 percent growth rate. This rate lies within the 15–20 percent range recommended in the New York Academy of Sciences report which dealt primarily with academic science research.

In the case of non-academic research, the 7 percent inflationary-complexity factor is again required to maintain constant levels of research activity. A firm guideline to growth of research activity is more difficult to define. It could be establshed on various bases such as: growth proportional to that of the GNP (in constant dollars), growth proportional to that of industrial technological development funding, growth proportional to changes in industrial sales or a combination of these factors. No clear-cut recommendations as to which of these growth factors should be used as a guideline basis have as yet evolved.

It must be noted that the factors which determine the magnitude of the annual growth rate guidelines, as outlined above, are keyed to: rate at which inflation occurs, the rate of increase of scientific and technological complexity, the rate of

graduate science student enrollment and the rates of growth of GNP, industrial development, industrial sales, etc. The magnitude of any of these factors can change as a function of time. Thus the calculations of these numerical factors have to be revised periodically. It should also be emphasized that the above-stated general guidelines do *not* cover cost increases produced by large science experiments with their associated high equipment and facility costs.

Question 43. What is your view of Dr. Brim's recommendation before the House Subcommittee to establish "a new kind of institute with the clearly defined purpose of carrying on applied social science research on problems of public significance"?

Answer· Dr. Brim's testimony was based on his work with the Special Commission on Social Sciences, appointed by the National Science Board, of which he is chairman. The Commission explored a number of proposals relating to possible new organizations which might be established. These ranged from entirely separate organizations such as the National Center for Atmospheric Research and the Brookings Institution to strong groups within a university, gathered together from several disciplines and oriented around a set of special problems. The Foundation has been following the work of the Commission and will give serious consideration to its recommendations, which soon will be published. The new program of Interdisciplinary Research Relevant to Problems of our Society, for which funds are requested, relates to these discussions and represents a planned effort to encourage multi-disciplinary groups of scientists working together on important societal problems. It is not expected that NSF will initiate any new institutes under this program, at least in FY 1970. However, if a university has an existing institute or wishes to set one up, we will consider proposals originating from that institute.

Question 44. What steps is NSF taking to improve the methodology for allocating limited resources between competing areas of basic and applied research: between research and education?

Answer. Methodology for the allocation of resources for scientific research must consider a number of factors. Allocation choices among a number of broad fields or problem areas in science are influenced by factors such as the number of qualified scientists, the number and distribution of quality institutions capable of supporting research, readiness or need of the field in view of recent theoretical or instrumentation advances, special instrumentation requirements, degree to which the field contributes to identified social needs, special opportunities offered, and degree of contribution by a given field to other fields. These plus other considerations are all elements of the decision matrix.

The Foundation has taken an active interest in the development of formal methodologies which could be used as tools by those making allocation decisions. Staff members have devoted time to such studies and external support has been given to allocation study projects to provide added insight. Examples of studies supported by NSF are: "An Exploratory Study of Science Resource Allocation" carried out by the RAND Corporation and studies of science allocation processes underway at MIT and George Washington University. The studies of the status and needs of various fields of science, which are carried out under the auspices of the Committee on Science and Public Policy of the National Academy of Sciences, with NSF support, also provide useful inputs to the allocation process.

With respect to the methodology used for the NSF choices between basic and applied research, the above considerations apply plus several additional factors. One involves the NSF decision not to fund applied areas of research at the expense of existing funding levels for basic research; another involves consideration of support provided by other Federal and non-Federal sources. Extra emphasis is placed on meeting identified social or technological needs and on the exploitation of special opportunities offered by specific areas. Other criteria for choosing special applied research areas for programmatic development by NSF have been developed. Such areas should meet several of the following requirements:

(1) Takes advantage of the close relationship of NSF to the academic community;

(2) Undergirds the missions of more than one agency;

(3) Has long-range goals beyond the normal program plans of mission agencies;

(4) Stems from scientific research programs supported by NSF, including interdisciplinary programs;

(5) Has no assigned "home" in a mission agency.

In supporting fields chosen through the use of these guidelines, both basic and applied studies will be accommodated, especially since there is frequently no sharp demarcation between basic and applied research.

Development of formal methodology for allocating support between research and education is at present inhibited by the complexity of the interdependence between the two activities. Research participation is a strong educational component at the graduate level of science education and, in turn, one of the chief end products and objectives of the latter is the maintenance of the national scientific and engineering manpower pool. Quantifiable allocation methodologies for decisions within research or among science education programs must be better understood before formal allocation strategies involving both can be developed. Nevertheless, better empirical solutions to the real problem of program and budget construction are sought by the Foundation through internal staff studies particularly represented in the annual Planning, Programming and Budgeting exercises. These require a careful examination of overall program goals, the effectiveness of programs underway and the consideration of alternative approaches. The relative contributions, opportunities and needs of research and education are annually examined in this context and in the budget construction phase which follows. Finally the assignment of resources between the primary programs of the Foundation is periodically reviewed by the National Science Board.

Question 45. What steps can be taken to make it possible for promising young postdoctoral scientists to compete effectively for research grants of their own, as opposed to serving as research associates on projects directed by more senior scientists?

Answer. The situation for promising young postdoctoral scientists varies widely from field to field. In some areas, such as biochemistry, it is normal for the best young men to be recruited into groups which are under the leadership of a senior man and are funded under a broad Federal grant or contract. Such men are normally given great freedom to do their own research and may supervise a group of graduate students. The postdoctoral scientist in such cases often serves to bring new ideas and techniques from his doctoral institution to the group he has joined. Under this regime, the best young men are generally not anxious to apply for grants of their own, and look forward to making such applications later in their careers.

In other fields, such opportunities are much more restricted. In engineering, for example, the Foundation has established a special program of "Research Initiation Grants" to help young research-oriented engineers get started. These non-renewable grants provide support for 15 months and are available to men within two years after receiving their doctorate. This program has been very successful, and most of the men supported have found assistance from other sources at the completion of their Research Initiation Grant.

In reviewing proposals, our staff and advisers are very well aware of the importance of encouraging promising young men, and their proposals always receive careful attention. It should be pointed out, however, that many young Ph.D's need and profit by a period of "apprenticeship" to a senior man after completing their doctorate. Furthermore, the necessity to write and re-write proposals and to undertake the administrative responsibilities of a principal investigator is not always compatible with the intense desire of the young scientist to devote himself fully to his research.

Finally, an increasing number of institutions have been able to find local funds to enable young faculty to get started in research. Some of our NSF institutional grant funds are used for this purpose, and a major aim of any new system of institutional or departmental grants would be to enable young scientists to start their work without recourse to the Federal granting systems.

Question 46. What steps can be taken to make science education more relevant to the youth of the nation?

Answer. Making education relevant is the single most important and, withal, the most difficult problem facing the schools and colleges today. The difficulty stems from the fact that what one segment of students (or faculty or administrator or employer) considers to be relevant is different from the view of another segment. Some students believe courses in the Swahili language are important and relevant; most do not. Some students (and educators) believe courses in Latin to be important; others consider Latin to be as irrelevant as Swahili. The student heading for a research career in theoretical physics knows that the calculus is relevant; the prospective business man has doubts. Moreover, students with quite different concepts of relevance are almost invariably

to be found in one classroom until at least the upper years of college. Hence, achieving relevance must, in the last analysis, rest upon the flexibility of the teacher and of the curriculum and upon the availability of a variety of teaching materials.

The Foundation's education programs include activities directed expressly to these ends.

The inflexibility of teachers stems in large part from their reluctance to depart from a highly structured, predetermined approach lest they find themselves beyond their subject-matter depth. The Foundation's several programs designed to increase the teachers' knowledge of their subjects and of the variety of ways in which a topic can be taught are based on a conviction that the teachers' mastery of the material tends to assure not only improvement in the nature of the content taught but that subject matter mastery develops in the teachers the kind of self-confidence that frees them of excessive rigidity.

Second, the teachers' competence and attitudes alone are not enough. They must have a variety of teaching materials from which they may choose those most suitable to their particular students. In addition, those materials should be such as to emphasize the learning rather than the teaching process; they should require active participation on the part of the students with guidance from the teacher. "Lecturing" the students should be minimized. Casting the *student* in the active role and affording him a variety of topics to study and modes of doing so, is basic to meeting the problem of relevance as the student sees relevance. The Foundation's support of the development of new and better courses, instructional units, and learning aids (films, books, laboratory devices) emphasizes contemporary content, variety, student involvement, and differences in learning styles.

Lastly, it is important that science be taught—other than in courses for specialists—as a part of the total experience of man rather than as an enterprise of and for scientists; scientists have no more ownership of science than historians have of history. This point of view must be implicit in both the teachers' attitudes and the instructional materials. Stated simply, science (its methods and content) are relevant to mankind's condition and can easily be shown to be so.

In particular it is important that the social sciences—which describe the structure and functioning of peoples' relationships to each other—should be realistic. The most salient fact of America today is the pervasiveness of social issues. Those issues have been much neglected in educational programs because they are uncomfortable to deal with. Probably the single most important step to increase the relevance of science education to today's youth is the re-shaping of the content of the social science courses. Through this mechanism students can be shown that the knowledge available to them through their schools can be useful in the "real world" from which they believe the schools are too detached.

Question 47. To what extent is it feasible to use science-education programs as a means for furthering national social objectives (e.g., combining the need for more technicians in the scientific enterprise with the goal of providing the disadvantaged with employable skills)?

Answer. There are a number of ways of answering the question depending upon how one defines science education (and the extent to which it differs from vocational education) and technical skill. For the present purposes, science education is considered to be education in scientific principles and methods as distinguished from manual skills. The scientific (or engineering) technician is here considered to be an individual who performs tasks that require both manual skills and a non-trivial understanding of the reasons for and import of his procedures. Although both definitions could validly be greatly broadened, within the context of the above definitions, science education—and not necessarily of a highly specialized sort—can be a powerful instrument in enabling the disadvantaged to obtain technical employment.

As we pointed out in background documents for the NSF authorization hearings, technical employment has certain characteristics that must be recognized when large technician-training programs are being considered. Briefly, these are the highly localized nature of employment opportunities, the non-mobility of the technician component of the labor force, and the short lifespan of specific technical tasks and with it the high obsolescence rate of the narrowly trained technician.

A good technician training program is one which finds the best compromise between sound education in depth and early employability, between the educational aims of the program and the educational attainment and competence level of the entering student, between programs that could enable the student to con-

tinue his schooling along more academic lines in the future and job-specific skills.

In the optimal program, the science education provides the student with an understanding of the phenomena with which he will deal as a technician. The greater his knowledge, the less likely he is to be displaced by technological advances and the more likely he will be able to advance or undertake further studies.

Much more can be done to provide many of the disadvantaged with employable technical skills than is being done. Two approaches are necessary. First, the regular elementary and high school instructional programs should make better provision for such students. This can be done—and to a limited extent is being done—by the development of some curricular materials with a more "practical" orientation than customary.

Second, separate and special instructional units and even courses need to be developed that have a more specific orientation to technological skills. The unit materials would give a teacher a mechanism for providing suitable technical understandings (and motivation) to individuals in a class; complete course materials, a mechanism for teaching a technological approach to entire classes of students when that is appropriate.

The Foundation's support of science education explicitly to aid the disadvantaged to become employable has been of small scale and mainly of an experimental nature. Although far from complete, these experiments have already disclosed a number of useful guidelines for a greatly expanded effort. In view of its primary statutory mission and financial resources, the National Science Foundation has no plans to markedly expand its activities with respect to the disadvantaged. A shift from an experimental to an operational level would require a substantial increase in Foundation resources, and would tend to shift the focus of the Foundtion's emphasis from strengthening the scientific capability of the Nation to one of social action.

Question 48. Does NSF consider existing mechanisms adequate for transferring funds from other agencies to the Foundation for use in the International Biological Program?

Answer. Adequate mechanisms do exist, and such transfers have been made. Admittedly, there are problems with the lead-time required if funds from other agencies must be re-programmed, and if their staffs are to have time to make independent judgments concerning individual proposals. Much of the support provided by other agencies for IBP will continue to be by direct funding rather than by transfer to NSF.

Question 49. If not, does NSF require additional funds in its authorization for this proposal?

Answer. The NSF Special Study on the IBP has projected legitimate requests for $15 million in new funding for IBP in FY 1970, and estimated at that time that NSF could appropriately support approximately $8 million of this total. The decision to request $5 million rather than $8 million in the NSF FY 1970 budget was dictated by an appreciation of the fact that support for scientific research generally will have to be held to a figure which is less than projections of legitimate need for all fields of science. The figure of $5 million represents, in a sense, a judgment as to a reasonable level for a high-priority activity in a year of expected budget stringency and a revised estimate of the rate at which various projects would be ready to start.

Prepared Statement of William T. Knox, President, Information Industry Association and Vice President, McGraw-Hill, Inc.

Mr. Chairman, Members of the Subcommittee: I welcome this opportunity to present to you my views with respect to the budget proposal for Fiscal Year 1970 submitted by the Office of Science Information Service of the National Science Foundation.

I have had considerable difficulty deciding from which viewpoint I should testify since I have been involved with scientific information in so many different capacities. In 1959, for example, I testified before the House Committee on Science and Astronautics, on the basis of my experience as a professional researcher, research manager, and director of an industrial research technical information service. Since that time I testified before the House Subcommittee on Science, Research and Development in my capacity as Chairman of the Committee on Scientific and Technical Information (of the Federal Council for Science and Technology) and

chairman of its National Systems Task Force, in addition to serving Dr. Hornig as his assistant on these matters. I was also a charter member and for two years chairman of the Science Information Council, which was created by the Congress in 1958 to advise the Office of Science Information Service. Currently and for the past two years. I have been employed by McGraw-Hill, Inc., a publisher of scientific and technical information in various forms and media. Most recently I have been an instigator in establishing a non-profit trade association of commercial information purveyors, which is called the Information Industry Association. I am currently serving as its president.

Perhaps I can best characterize my viewpoint this morning as being that of a deeply-interested citizen, with my current biases emphasizing the role of the commercial information industry and the importance of the industrial research community.

It is now ten years since the Office of Science Information Service was created. As you are well aware, it was created by the National Defense Education Act of 1958, and was not a part of the original enabling legislation for NSF. From its beginning OSIS has been an unusual operation within NSF. OSIS was requested by the Congress "to provide or arrange for the provision of" better information services for the scientific and technical community. In a functional sense. OSIS was thus asked to provide or arrange for the provision of on-going information operations—not research, but development and operation of services. This is quite a different ballgame than the dominant one played by the NSF: namely, supporting basic research and education in the scientific disciplines in our colleges and universities.

I have stressed the unusual character of the OSIS mandate because some of the characteristics of its program may be largely due to the difficulties of operating a program which directly affects large, long-established information services serving the general scientific and technical community, when the dominant tone of the overall NSF organization and its administrative guidelines and regulations respond to the needs of university-based research and education.

You are aware, I feel sure, that the great bulk—71%—of U.S. scientists and engineers engaged in research and development are employed in private industry. and only 15% in universities. Thus the greater part of the usage of scientific and technical information takes place within industrial research.

OSIS was established as a direct outgrowth of the Congressional concern over the launching of Russia's Sputnik I, and some highly publicized statements that had this country had better access to Russian literature in science and technology it would not have been caught napping.

The basic premise on which OSIS was established and which has guided many of its programs was that all the worldwide literature in science and technology should be widely disseminated across the nation. The underlying theory was that there was a scarcity of available information, and the remedy was to translate a lot of foreign literature and publish more of our own.

So much for the background. If I were asked to characterize the OSIS operations over its first ten year's operation I would say that it had valiantly tried to live up to its responsibilities. However, because of the general NSF atmosphere and the stress placed by the university-dominated President's Science Advisory Committee on the professional scientific societies' role in scientific information, OSIS has given little attention and less support to the vital role played by commercial publishers and other types of information entrepreneurs, especially in relation to industrial research and the technological community.

Let me quote from the NSF FY70 Budget proposal. "The System Development and Improvement program ($7.6M) assists professional societies. In development of systems, the Foundation works with the most representative scientific societies since the scientific community in each discipline should be responsible for the design implementation, and operation of the information system that will serve its requirements."

The tens of millions of dollars granted by NSF for the development and operation of more adequate information services in the scientific and technical information community have almost without exception been placed with not-for-profit enterprises, especially the professional societies.

In addition, other support programs have been restricted to the not-for-profits. As an example, let me cite the "page charge" policy which was initiated by OSIS, and after endorsement by the Federal Council, followed by all Federal agencies. Under this policy, a large fraction of the costs for publishing research results are paid by Federal agencies, provided the publisher is a *not-for-profit* organization.

This not only penalizes existing commercial publishers but effectively inhibits new commercial ventures and ensures the continuing growth of the not-for-profits.

The reliance placed by OSIS on the professional scientific societies has also resulted in OSIS taking a traditional approach to the scientific information problem. Professional societies, operating as they do through voluntary efforts and dues paid by their members, are generally very conservative organizations.

In addition, they are relatively weakly managed, with a cumbersome committee and administrative structure. A good deal of effort by Dr. Adkinson, the head of OSIS since its inception, has been spent, therefore, trying to convince the various scientific societies that they should do something about the scientific information situation in their discipline, and that they would be willing to accept his help. This was not easy.

How different the situation might have been had equal effort been placed to awaken the commercial information industry to the importance of providing better scientific and technical information systems and services, with government funding available to cover the market research, development, and systems design and implementation costs. In spite of the repeated, firm denial of such encouragement from OSIS, a few commercial firms, at great financial risk, have entered some areas of the scientific information field. Their courage deserves praise and more support.

The Congress would do well to ask OSIS to justify its stated objective to create "one principal source for all pertinent scientific information for each major discipline." This sounds like a set of monopoly operations created within professional societies by Federal administrative action. What criteria will determine the selection of the one source? What criteria will govern the scope of its coverage and the number and type of services it renders? What agency will regulate the monopoly in the public interest? What will be the regulatory procedures and criteria?

Let me now turn to some pressing operational problems. A lot of effort—tens of millions of dollars each year—goes into publishing research results and subsequently abstracting and indexing the original publications. This is the traditional area of operations for the professional societies. It is a library-oriented, archival approach. Each original article gets the same treatment, although it is freely admitted that the great bulk of these articles are never referred to by other scientists. Part of the problem is caused by the "publish or perish" syndrome in the universities. Part of it is simply the inertia of tradition. The more innovative people concerned with information services in the professional societies agree that primary journal publication has long since passed its peak of usefulness, and that it now primarily serves the author's purposes rather than the user.

The user needs to have access to a variety of information services tailored to his specific needs. These services must also be flexible and change with the user's changing needs. This is the type of function best served by the commercial information industry. The commercial information industry serves its users well, or it goes out of business.

What should OSIS do about this? Is OSIS, through its page charge policy, and through its exclusive reliance on professional society publication, abstracting and indexing policies, perpetuating an obsolescent practice? Is this in the best interests of the users? Why is OSIS still budgeting substantial sums for support of primary journal publication?

As an example of alternatives, the Weinberg panel reported, as others before had suggested, "An attractive technical solution to the problem of the dissemination and retrieval of documents is the centralized depository. Perhaps the main obstacles to its adoption may come from the attitudes of some elements of the technical community itself."

NSF has provided massive financial support to encourage several professional societies to computerize their abstracting and indexing efforts. I think fair questions for this subcommittee to ask are the following: If Federal support predominates in the establishment of these new computer-based abstracting and indexing services, what assurance is there that the various services do not duplicate each other's effort? Should OSIS anticipate the possible desirability of a complete Federal subsidy of these operations?

In a very real sense, a complete Federal underwriting of the abstracting and indexing operations would be analogous to Federal underwriting of the compilation of information by the U.S. Geological Survey. In both cases a service of general, non-specific interest is rendered. No one knows in advance whether certain geological survey data will be useful; neither does one know about an

abstract or an index to a journal article. Such subsidized abstracting and indexing operations could, of course, be under the managerial control of professional scientific societies.

One major prefssional scientific society has already begun to view its role as a wholesaler of abstracts and indexes. This is a step forward. It recognizes the relative inflexibility of professional societies to respond with different information products and services to the rapidly changing user requirements. It also recognizes that the management of a very large information operation demands full-time, high quality talent, and may overwhelm the other functions which only a professional society can serve for its members.

I wonder, therefore, whether OSIS in the next ten years should not be as aggressive in underwriting the attempts of commercial enterprises endeavoring to develop better information systems and services for scientists as it has been in the past ten years with the professional societies and other not for profits. Amending legislation or Committee recommendations may be required, but I have never found the Congress unreceptive to suggestions from the taxpayers.

Thank you again, Mr. Chairman, for the opportunity to testify.

Prepared Statement of W. Frank Blair, Chairman, U.S. National Committee, International Biological Committee, National Research Council

Mr. Chairman, members of the Subcommittee, the National Science Foundation (NSF) program for FY/70 includes a "line item" of $5 million for the International Biological Program (IBP). Since I am Chairman of the U.S. National Committee for the IBP, I submit the following statement as added background for your analysis in context with your review of the NSF Program for the coming fiscal year.

WHAT IS THE INTERNATIONAL BIOLOGICAL PROGRAM (IBP) ?

The IBP is an international program of research on biological productivity and the biological basis of human welfare. Fifty-seven nations now participate under sponsorship of the International Council of Scientific Unions (ICSU). All major nations with the exception of Red China are participants. The latest to join are Malawi and Panama.

International management of the IBP is effected by a Special Committee for the IBP (SCIBP) with offices and secretariat in London. The SCIBP secretariat is supported financially by national dues that range from $25,000 annually down to only $500 for undeveloped countries. Some of the latter pay no national dues, but for the overall benefit of all participants, they are included.

In the United States, the planning and management of the national participation in the IBP is the charge of a committee of the National Academy of Sciences. The coordinating agency for Federal participation in the IBP is the National Science Foundation. An Interagency Coordinating Committee (ICC) is chaired by the Director of the Division of Biology and Medicine of NSF; it was established as a result of a request from the Chairman of the Federal Council for Science and Technology asking NSF to "move expeditiously to explore the optimum nature and extent of federal agencies' involvement with this Program".

National programs range in sophistication from such programs as that of the United States and the relatively sophisticated program of the U.S.S.R. down to very simple programs in some of the developing countries. Nevertheless, there is international cooperation and coordination among 57 countries to solve problems of man's welfare in a deteriorating global environment. Furthermore, cooperative projects involving the technologically advanced countries and the developing countries are providing a stimulus for scientific advance in the latter.

WHERE ARE WE TIME-WISE?

The second of the 5 years of the so-called action phase of the IBP will end on July 1 of this year. Even so, the U.S. effort has not reached full activation of the program of participation in the IBP planned by the U.S. National Committee.

The reasons for this delay are twofold: (1) There has been inadequate financial support, and (2) the development of the U.S. program has involved the emergence

of a novel and sophisticated approach in environmental biology. Several Integrated Research Programs (IRP's) form the heart of the U.S. participation in the IBP. Since there has been essentially no precedent for this kind of biological research, the planning and implementation of these IRP's has been slow. However, we have full confidence that we have now reached the stage where the only possible obstacle to the success of the U.S. program might be inadequate funding. The U.S. program is described in the recently published Report No. 3, Part 2, of the U.S. National Committee.

WHERE ARE WE FINANCIALLY?

The U.S. participation in the IBP has not received adequate financial support to mount the imaginative and timely (with respect to environmental problems) program of research that has been generated by the U.S. National Committee and its subcommittees.

Financial support for planning of the U.S. participation in the IBP and for the central office has been provided by "passing the hat" among interested Federal agencies. This support has been quite adequate. *Research funds have been another matter.* Through Fiscal Year 1968, all research done under the IBP in the United States was done through reorientation of existing research programs or through reprogramming in agency budgets that provided an estimated $689 thousand of "new money." In Fiscal 1969 there is a "line item" of $500 thousand in the NSF budget; and NSF and some other agencies have reprogrammed additional amounts into IBP interdisciplinary studies; the total this year is approximately $1.3 million.

A joint resolution was introduced into the 90th Congress by Congressman George Miller of California and Senator Fred Harris of Oklahoma authorizing $3 to $5 million of new money for the IBP in FY/69. In hearings in the House Subcommittee on Science, Research, and Development, on May 1 and 2, 1968, the Deputy Director of OST presented the Administration's stringent financial policy and opposed the funding provisions of this resolution; however, fully supported the subjective goals of IBP and U.S. participation.

In the summer of last year, a budget study of the IBP was made by NSF at the request of the BOB. As a result of this study, there is a "line item" of $5 million for the IBP now in the NSF budget—and under consideration by your subcommittee. The NSF position was that approximately $15 million would be needed in FY/70, and that the remaining $10 million should be found in the budgets of other interested agencies.

The figure of $15 million new money represents a hard estimate of the needs of the U.S. participation in the IBP that was arrived at after much consideration by the U.S. National Committee for the IBP and by NSF. Attachment 2 indicates the approximate planned distribution of this $15 million among the IRP's that make up the U.S. participation in the IBP. The current and previous year's support is shown in Attachment 1.

In an attempt to facilitate the participation of various interested Federal agencies in the funding of IBP research, joint resolutions were introduced—S.J. Res. 89 by Senator Edmund Muskie and several cosponsors in the Senate and H.J. Res. 589 by Congressmen Miller and Daddario in the House. Among other things, this resolution "authorizes and requests all Federal departments and agencies having functions or objectives which coincide with or are related to those of the international biological program to obligate or make appropriate transfers of funds to the program from moneys available for such functions or objectives and provide such support as may be appropriate."

As I have already testified in House Committee hearings on this resolution, I am strongly in favor of its provisions. Section 2, vigorously applied, should result in an IBP budget program including participation of agencies which have not previously budgeted for the IBP.

WHAT ARE THE POTENTIAL ACCOMPLISHMENTS OF THE IBP?

The IBP is not just another program in science. It represents the first massive international effort to understand the functioning of the ecosphere, the whole global system of physical environment and organisms of which man is a part.

The IBP will provide baseline data pertinent to the functioning of world environments. It will provide knowledge needed for environmental management and for credible approaches on many of our problems on pollution and environ-

ment. It will not solve those problems; but essential understanding gained will allow others to plan more adequately.

The IBP has already generated the kind of new approach in environmental and human ecology that is needed if we are ever to understand the functioning of the earth's ecosystems and hence be able to manage them to man's advantage. This is the interdisciplinary team approach involving large national and international groups of scientists working cooperatively on various components of the same major problem and collating their results centrally with the ultimate purpose of treatment of the whole ecosystem by the methods of systems analysis.

The U.S. participants in the IBP have been responsible for the development of this new approach, and our Grasslands Biome study at the Pawnee site in Colorado has progressed at a rate and in a manner far exceeding the most optimistic original expectations. With the Grasslands Biome study as a successful prototype, the 5 other projected biome studies (desert, deciduous forest, coniferous forest, arctic and alpine tundra, tropical forest) representing major geographic areas of the United States and the internationally important tropical forest, have developed through the planning stage at a much more rapid rate than we had anticipated. The planning has thus outrun the visible funding for these important studies.

The IBP research, in conjunction with the mounting concern about environmental quality, has already stimulated an increase in the production of the scientifically trained ecologists who are going to be essential to the environmental management that must come very soon if we are to halt the accelerating deterioration of global environments.

Finally, the IBP has generated a spirit of international cooperation in scientific inquiry that has never existed before in any aspect of biological science. Scientists of 57 countries participate and cooperate in the exchange of information and in the standardization of methods so that their results can be compared. In addition, there are numerous multinational teams in the IBP. In the U.S. program, this international effort is central in the organization of several IRP's, especially: (1) Biological Production in Upwelling Systems, (2) International Study of Eskimos, (3) Population Genetics of the American Indians, (4) Biology of Human Populations at High Altitudes, (5) Nutritional Adaptation to the Environment, and (6) Convergent and Divergent Evolution. The main component of the last has a team made up of scientists from 7 South American countries, Panama, Mexico, Australia, Puerto Rico, and 12 U.S. states. The Hawaiian component of this IRP has participants from Hawaii, The Philippines, Japan, India, Scotland, and from 9 states in the continental United States.

These cooperative international projects, where they involve the technologically advanced and the developing countries, promise to pay large dividends in upgrading environmental science in the latter countries. As might be expected, the international participation by the United States is weighed heavily toward Latin America. Environmental problems are to a large extent global problems, so we have a vested interest in establishing and acquiring environmental knowhow in the underdeveloped countries of the world, and especially in those of neighboring Latin America. In addition, we can expect that the growth of basic science and of improved resource management in the underdeveloped countries will contribute to their political stability.

AFTER IBP, WHAT?

The IBP is administratively scheduled to end in 1972. However, all closely involved in the IBP believe that the major international and the highly programmatic studies (e.g., ecosystem analysis) will continue. The biome studies, which form such a major part of the U.S. participation, may well be continued under some such umbrella as that of a national institute of ecology, which has been recommended by the Ecological Society of America and which has received the attention of committees of Congress. Some of the highly international programs may proceed under the umbrella of intergovernmental agencies such as UNESCO and FAO, both of which have expressed interests. Others may proceed under a non-governmental umbrella such as ICSU. The interdisciplinary studies begun with IBP will form the basis for interagency and multinational efforts needed so that we may better understand the environment, its quality, and the effects on man.

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ATTACHMENT 1

ELEMENTS AND SCHEDULES, US/IBP, FISCAL YEAR 1970

[Dollars in millions]

IRP	To be submitted (Quarter and years)	Amount
Environment component:		
Analysis of ecosystems	4th, fiscal year 1969	$0.275
Grasslands	do	2.209
Deciduous forests	3d, fiscal year 1970	2.275
Desert	4th, fiscal year 1969	1.700
Coniferous forest	3d, fiscal year 1970	.900
Tropical	do	.080
Tundra	2d, fiscal year 1970	.200
Convergent/divergent evolution (including Hawaii)	4th, fiscal year 1969 and 1st, fiscal year 1970.	1.100
Aerobiology	1st, fiscal year 1970	.500
Marine mammals [1]	do	.175
Biological control [2]	do	.500
Conservation of genetic materials [3]	do	.077
Biogeography of the sea [4]	4th, fiscal year 1970	.300
Phenology	2d, fiscal year 1970	.280
Psysiology oc colonizing species	1st, fiscal year 1970	.400
Upwelling	3d, fiscal year 1970	.125
Human adaptability component:		
Urban and migrant peoples [5]	do	2.610
American Indians [6]	1st, fiscal year 1970	.240
Nutrition [7]	do	.290
Eskimos	Continuation	.200
High altitude people [8]	4th, fiscal year 1969 and 1st, fiscal year 1970.	.600
Chronobiology [9]	2d, fiscal year 1970	.200
Total		15.236

[1] Marine mammals is now identified as a "potential IRP" and the USEC/IBP has encouraged the originator to fully develop the program. A draft proposal has been submitted. Funding needs and approximate date for proposal submission have been verified.

[2] Biological control is now identified as a "potential IRP" and the USEC/IBP has encouraged the originator to fully develop the program. Proposal has been submitted. Funding needs and approximate date for proposal submission have been verified.

[3] Above notes also apply to conservation of genetic materials. This proposal will originate from ARS–USDA, and a draft has been submitted. It will involve both in-house and non-Government effort. It is not budgeted in ARS. It was identified by SCIBP circa 1964 as an essential IBP effort. With USEC/IBP endorsement proposal will seek support either by interagency transfer from NSF to USDA, or by reprograming within USDA.

[4] Central program proposal on biogeography of the sea has been shelved (rejected) by NSF. There is a high probability that a program proposal on estuarine ecosystem analysis will develop under the guidance of PROCOM. If this reoriented IRP develops, projects now identified with biogeography of the sea may be subsumed under the reoriented IRP.

[5] Central program proposal for urban and migrant peoples is not yet satisfactorily developed. Research projects in this program are developing; e.g., the "Holmes County" project is supported at $180,000 per year, the "Chicago" proposal now under review in HEW requests approximately $100,000 for fiscal year 1970. The "Miami River Project" will request approximately $600,000 for fiscal year 1970. Plans are underway for central program coordination and synthesis. These plans should produce a central proposal by the 3d quarter of fiscal year 1970.

[6] The current IBP identified portion of the AEC supported research on genetics of American Indians is $150,000 per year in a total AEC program of $358,000 in fiscal year 1969. The total IBP effort required on this IRP is $390,000 for fiscal year 1970. The originator will be request $240,000 additional for fiscal year 1970. Request will be addressed to AEC and will suggest that AEC seek interagency transfer from NSF since this latter amount is not budgeted in AEC.

[7] The fiscal year 1970 amount shown on the Nutrition IRP assumes that the $40,000 initiating proposal will be funded in fiscal year 1969. The $290,000 fiscal year 1970 program includes continuation of the central coordination at $40,000 per year plus $250,000 of new research.

[8] The high altitude IRP proposes coordination at no cost between principal investigators at Pennsylvania State University, University of Colorado and University of Wisconsin. The Pennsylvania State proposal at approximately $200,000 will be submitted during the last quarter of fiscal year 1969. The University of Wisconsin proposal was submitted to NSF approximately 4 months ago. The University of Colorado proposal will be submitted 1st quarter of fiscal year 1970.

[9] Chronobiology has been identified by the USEC/IBP as a "potential IRP" and the originator has been encouraged to develop and submit this IRP proposal first to the USEC/IBP for internal evaluation and then to NSF for support. The funds required and time of submission have been verified.

Attachment 2

Agency/IBP Support—Fiscal Years 1968 and 1969

The following table lists Integrated Research Programs of the International Biological Program supported in FY 68 and 69 and the agencies providing support. In the column headed "Origin," we attempt to differentiate between research on IRPs (1) that existed prior to IBP, and (2) that was initiated because of IBP. Likewise in the subtotals under FY 68 and FY 69, we differentiate between these amounts. These subtotals provide some indication of funds preprogrammed

within agency budgets as distinguished from reprogrammed funds made available because of IBP. *All may be said to be mission funds; and all may be said to directly support IBP–IRPs.* This table shows $3.8 million granted in FY 69 in support of IBP–IRPs of which $1.3 million was granted as a result of IBP initiation.

MAJOR IBP STUDIES SUPPORTED

[Dollars in thousands]

Major study	Supported by	Origin	Granted fiscal year 1968	Granted fiscal year 1969	Requested fiscal year 1969, pending
Environment:					
Analysis of ecosystems	NSF	IBP	[1] $224.3		
Grasslands	NSF, AEC, USDA	IBP	[2] 424.2	$451.0	[3] $2,209
Desert	NSF	IBP		20.2	
Deciduous forest		IBP			[3] 230
Coniferous forest	SI	IBP		[1] 30.0	[3] 31
Convergent/divergent	NSF, HEW	Pre-IBP	162.5	105.2	
Evolution	USAF	IBP		126.1	
Aerobiology	NSF	IBP		51.7	
Biogeology of the sea	NSF, USDI	Pre-IBP	50.0	45.0	[3] 66
	SI	IBP		67.4	
Upwelling ecosystems	NSF	IBP		94.2	
Human adaptability:					
Internal study/Eskimos	HEW, SI, USAF Wenner-Gren.	IBP	40.6	[4] 312.5	
Migrant peoples:					
Chicago		IBP			[5] 99
Mississippi	HEW	IBP		180.5	
Biological human population/high altitude		IBP			[3] 140
Population genetics/American Indian	AEC	Pre-IBP	150.0	150.0	[6] 358
		IBP			[6] 240
Nutrition:					
Central	Army, USDA, AID, HEW.	IBP			[3] 39
Research	Universities and private sources.	Pre-IBP	3,452.0	2,203.0	
Subtotal IBP originated			689.1	1,333.6	3,054
Subtotal pre-IBP			3,814.5	2,503.2	358
Total			4,503.6	3,836.8	3,412

[1] 2 years.
[2] 7 months.
[3] National Science Foundation.
[4] 3 years.
[5] Health, Education, and Welfare.
[6] Atomic Energy Commission.

PREPARED STATEMENT OF DR. THOMAS G. FOX, SCIENCE ADVISER TO THE GOVERNOR OF PENNSYLVANIA, CHAIRMAN OF THE GOVERNOR'S SCIENCE ADVISORY COMMITTEE, AND CHAIRMAN OF THE BOARD OF THE PENNSYLVANIA SCIENCE AND ENGINEERING FOUNDATION

SUMMARY

The NSF authorization and appropriations document in Congress has proposed to proceed *in low gear* on studies of how states can mount effective programs for use of science and technology to benefit their economies and to solve their urban and environmental problems; *in high gear* to fund in the universities long-range social and engineering studies on the roots of our urban problems.

In the Commonwealth of Pennsylvania we have in the past six years combined these two objectives.

Our program brings together sophisticated people from our universities from industry, from the professions, and from government to foster creative engineering of new concepts and new approaches to our problems.

We are thus led to propose to Congress and the NSF that these two NSF programs be—

combined to provide one of the approaches of NSF to the interdisciplinary studies

given there by a more innovative, problem solving, engineering slant, with emphasis on new concepts

designed thus to bring together university thinkers, and as client-sponsors, practical people from industry and government, who know the problems and can implement the solutions.

The Proposal would multiply NSF funding by requiring matching funds from each state. The joint interest and involvement of NSF and state agencies should provide means of multiplying the effectiveness of both the state and Federal efforts. The involvement of NSF should maximize the opportunity to export the lessons learned in one state to early application (when appropriate) in other states isolated geographically or otherwise from each other.

Of course, direct NSF funding of universities on interdisciplinary programs on engineering-social problems is not precluded by this proposal.

Our proposal is presented under the following headings:

As background material we have included the following appendices:

*These two appendixes are held in the files of the subcommittee.

BACKGROUND

Measures of the nation's scientific and engineering programs include (1) their intellectual quality in advancing knowledge and (2) the vigor with which they apply this knowledge to meet human needs. It has been demonstrated that the nation will support the scientific community fully if the public understands that the latter goal in particular is met.

Speaking broadly on the application of science, the U.S. experience in this century may, perhaps, be categorized under three main headings:

First Period—Science for Industry

In the first third of the century we learned how to organize research and development undertakings in industry to speed technological progress in selected areas. The universities grew and adapted to support this effort through basic research and training of scientists and engineers.

Second Period—Science for Defense

In the middle third of the century we learned to mount massive national undertakings to action technological progress in areas vital to our national defense. Congress, Federal agencies, our university communities, and the new aerospace industry which had to be established to meet these national goals, learned to work together to supply the basic knowledge and developmental apparatus on a systems scale required to do the job effectively.

Third Period—Science for Society

In the last third of this century our nation is faced with critical urban and environmental problems whose solutions involve both technological and social factors. We are challenged to learn how to use our knowledge and resources effectively to insure technological and social progress. There needs to be a revival of engineering scholarship in the broadest sense with close participation by federal, state and local governments in industry and in new partnerships—working together or in coordinated fashion with joint responsibility in ways as yet undefined.

It must be emphasized that *unlike defense and space technology* applications of science and engineering to environmental and urban engineering problems requires leadership not by the Federal government and its agencies alone but also necessarily by state and local governments. These necessarily must mobilize local talent and will adapt to local circumstances and desires the technology and concepts which emerge from the national programs. Thus it is essential that EVERY STATE DEVELOP STATE SCIENCE POLICIES AND PROGRAMS marshalling local resources to engineer solutions to local problems and further that FEDERAL AND STATE SCIENCE PROGRAMS BE CLOSELY COORDINATED SO AS TO REINFORCE EACH OTHER.

PENNSYLVANIA SCIENCES PROGRAMS

We in Pennsylvania are concerned with *both* the generation of new scientific knowledge *and the effective use* of scientific knowledge and technology to solve our urban and environmental problems and to keep our state's economy strong. To this end we have the past six years forged strong lines of communication and effective partnerships among state and local governmental units and the engineering and scientific communities in universities and in industry in Pennsylvania.

The Governor's Science Advisory Committee (GSAC) has for six years advised on state science policy. The Pennsylvania Science and Engineering Foundation has for two years, with Commonwealth funds of 1.4 million dollars annually, initiated engineering programs within Pennsylvania's universities and other research organizations to solve our local problems and to advance our economy.

Material describing the Pennsylvania Science Program is given in Appendix IV and a report on a specific example of Federal-State funding of a consortium of universities and research institutions to engineer new approaches to preserve and utilize more effectively the Delaware River and Estuary as an important natural resource is given in Appendix V.

Consideration of this evidence will show that we have succeeded in Pennsylvania in generating a state science policy and a state-oriented program in science and technology which, through investment of state funds, and participation of some of the best minds in our universities, in industry, in government, and in the professional community, is making a strong beginning in focusing our resources on programs aimed at solving urgent problems. The solutions necessarily involve new engineering, new technology and considerations of cost, economic impact, of law and government, and of what the people desire.

We believe we are generating a partnership between government, universities, industry, and the local communities and professions to work together on acceptable and effective *solutions*.

The flexibility and broad scope of NSF involvement in science and engineering in the university combined with our state's interest in the needs of the Delaware greatly aided us in establishing a Center of the scope and nature required to engineer new approaches to the Delaware problem. Involvement on the Center's policy and technical advisory committees of representatives of Federal, State and interstate governmental agencies and of industries all having practical interests in the Delaware insured the necessary communication between the unversity innovators and the ultimate users required to promote both producibility and effective use of the results. The growing interest in and support of specific projects at the Center by many Federal and state mission-oriented agencies indicates the value of such Centers once established.

In recent years, Connecticut, New York, Georgia, Illinois and other states have generated state science policies and state-oriented programs similar to those of Pennsylvania. Many of the states are now aware of the value and necessity of such programs and are searching for ways to structure them in their own circumstances.

PENNSYLVANIA PROPOSALS TO NSF

The NSF has proposed to Congress separate programs—

to study how state science programs can be formulated to serve the specific needs of the individual states.

to mount university interdisciplinary studies on social problems.

Our experience in Pennsylvania in the past six years in the use of states science programs to marshall our resources to meet our problems and opportunities convinces us that there must be more effective coupling among universities and the local government units and industries who have the problems and have the responsibility for the programs aimed at their solutions.

Thus, we are led to suggest to NSF, as one approach at least, they look into the desirability of giving greater support to state-oriented interdisciplinary engineering programs on social problems to establish new patterns of communication and cooperation that should play a vital role with various Federal agencies and programs in effectively bringing modern engineering scholarship to bear on Science for Society.

This should also strengthen the research capabilities of state governments and enable this level of government to play a greater and proper role in the utilization and the shaping of science policies. As yet very few, if any, state governments have realized the full potential of using available resources and scientific knowledge in coping with public problems. They are faced with the

difficulty of working with highly differentiated (and fragmented) Federal programs which often impede efficient and effective handling of problem situations. In large measure, the difficulties arise from inadequate state activities and representation in national policy-making processes. Our proposal represents an effective path toward correcting these critical deficiences in our national effort.

PROPOSED POLICY

The following propositions are, I believe consistent with the above ideas and furnish the basis for the proposal which follows.

Science and Technology can and indeed must contribute to the solution of urban and environmental problems.

There exists both need and opportunity to focus present knowledge and skills in diverse disciplines upon innovative approaches to our problems. This amounts to advancing new engineering concepts—a proper function both for universities charged with engineering scholarship for industry which supplies technology.

Applied science develops best when there exists a strong interaction between the innovator and the community for which the developments are intended. This is especially true when political, economic and social factors, as well as technological factors, determine the acceptability of the new development.

Problems of housing, transportation, environment, education, health services and others are necessarily a responsibility of state and local, as well as Federal government. Local approaches to these problems are dependent on the resources and needs of the state or region involved. Consequently, it is not only desirable but necessary that there be mounted in each state determined state-oriented programs.

The National Science Foundation with a broad involvement in supporting science and engineering, and university education, is an appropriate agency to foster innovative engineering to meet the problems of the communities. Thus, it is positioned to initiate programs that avoid both isolation of efforts (of universities, industry and governmental units) and fragmentation of problems (e.g., transportation, housing, environmental control, health services), enabling other single-mission agencies to support appropriate aspects of the new programs as they develop. The communication, through NSF, of successful ideas from one state or region to another should also be expedited.

It follows that National Science Foundation support is desirable (a) for the development of state-oriented science programs in each state and (b) for programs structured by the state agency in each state so as to involve in concerted fashion its engineering resources in attacking state problems and to promote continuing communication with the appropriate government, professional, and industrial communities. (See Appendix III for Remarks.)

PROPOSED PROGRAM

It is desirable:

1. To encourage a sophisticated examination at the state (or regional) level of the scientific and technological resources and needs of the state and of effective means of harnessing these resources to solve the environmental and social problems of the state including economic growth.

2. To encourage university and other groups' attention to the urgent state and local problems, with a view to promoting interdisciplinary innovative approaches to solutions.

3. To insure that university involvement is coordinated with those government, professional, and industrial elements of the community that will have to act in adopting or delivering the new solutions.

4. To insure that the broad Federal programs, as represented, for example, by NSF support of science in the universities, strengthen the needed state efforts and facilitate cooperation between state and federal mission-oriented science and technology programs.

To this end we propose:

1. That the NSF immediately take steps to assist the states (or regions) in the creation of State Science Councils, charged with developing programs of using state resources to meet state needs.

The NSF could provide for the purpose of promoting the Science Councils matching funds to each state at ratios, for example, of $75,000/25.000, Federal/state the first year; $50.000/50,000, Federal/state the second year; $25,000/75,000, Federal/state the third year.

(In implementation, the NSF would need to draw up statements of goals and suggested structures of these state organizations, and criteria for acceptability. NSF should plan in-depth briefing on a continuing basis as needed to advise state representatives as to useful approaches.)

2. That the NSF institute demonstration projects with matching federal-state support, of interdisciplinary applied programs in universities and nonprofit institutions with appropriate governmental and industrial participation. Each program would be initiated by the state as an effort to meet environmental and social problems. Such support should be sufficient to represent an appreciable impact on the use of state resources—hence it might have an upper limit of perhaps $1,000,000 per state. Obviously, only a few states will be able to meet these in the early years. Thus, the total cost is not likely to exceed $5,000,000 per year for the first few years.

3. That the NSF on the basis of experience gained in the demonstration projects institute programs of this type with each of the states offering matching funding. Obviously, the formula for matching state funding should be related to needs and capability. Perhaps formulas for maximum matching funding based on population, say perhaps $100,000 for each million in population in the state would be equitable.

REMARKS

This proposal is similar to the program plan advanced at the NSF-Southern Interstate Nuclear Board Conference (involving 32 states) on Science, Technology and State Government in Louisville, Kentucky, September 19–20, 1968. (See Appendix I)

PROPOSED CRITERIA FOR THE NSF-STATE DEMONSTRATION PROGRAMS

1. Programs submited by the state science board are designed to meet the state's environmental and social needs and utilize more effectively the resources of the state.

2. Individual projects are directed at the problems or opportunities within the state, with promise of applicability in other states generally.

3. Individual projects should be preferably interdisciplinary and interinstitutional.

4. Projects are to be conducted with effective communication among the appropriate government, professional, and industrial agencies and institutions, acting as advisory bodies or as joint client-sponsors or in other arrangements to couple development with potential users.

5. Projects can be funded by grants or contracts with universities or nonprofit institutions, including state or local government agencies, or by contract with industry.

6. In general, the project should better mobilize the state's scientific and technological resources in concentrated effort to innovate, demonstrate, or promote new conceptual and/or technological approaches to local problems or opportunities and to train professionals and students in the disciplines required for their implementation. Ideally, the project provides a focal point for input from all appropriate elements of the community to define the problem and find new solutions.

SPECIFIC ACTIONS

NSF should consider:

1. Establishing a commission to make recommendations on specific policies, programs, criteria, etc. Such a commission should file a final report in no more than six months, and sooner if possible.

The commission may consist of ten to twenty members, representative of universities, industry and state and federal government. If individuals such as Drs. Hollomon, Hornig and others, who are particularly familiar with the problems at the state level, are selected, it is conceivable that recommendations could be forthcoming in three or four months.

2. In operation, an Assistant Director of NSF could be given responsibility for these State Interdisciplinary Science Programs. In general, he would determine whether programs submitted by the state meet the NSF criteria. Difficult cases could be referred to a special advisory board similar in composition to the aforementioned commission.

NSF FUNDING

The following estimate of appropriate NSF funding levels of the three programs proposed here are presented for consideration.

State Science Council

First year	33×$75,000=$2,425,000
Second year	33×$50,000=$2,925,000 17×$75,000
Third year	33×$25,000=$1,675,000 17×$50,000
Fourth year	17×$25,000= $425,000

State-Engineering Demonstration Projects

First year	$5,000,000
Second year	6,000,000

Ongoing State Engineering Projects

Fifth year	$20,000,000 to $25,000,000 per year.

A PROPOSED AMENDMENT: TO GIVE SUPPORT TO THESE PROGRAMS WE HAVE RECOMMENDED EARLIER THE FOLLOWING DRAFT OF AMENDMENT TO H.R. 4283

To Be Inserted in H.R. 4283 as Section 3(d)

(d) Not more than $5 million of the amount authorized for support of scientific research may be used for interdisciplinary research relevant to the problems of our society: and of this amount no less than $3.5 million shall be used to establish a national program in cooperation with State Governments for the support of scientific research relating to the problems of state and local governments, and the strengthening of scientific research potential in the several state governments. Of the amount authorized for planning and policy studies, no less than $750,000.00 shall be used for planning activities directed to this national program.

Note: The amount for planning and policy studies in Section (1)(7) should be authorized at $3,500,000 to provide for this increased state planning activity.

Appendix I

NSF–SINB Conference Program Proposal

(1) Science and technology is an essential ingredient of social and economic progress, and is providing new tools for the solution of today's complex problems—such as in crime control, transportation, use of information for decision making, planning and measurement of progress, to mention a few.

(2) The federal government has, over the years, invested heavily in the creation of new knowledge and more recently in information systems for the dissemination of knowledge.

(3) The use of new knowledge being created by the great science effort of the federal government requires a significant state and local involvement.

(4) At the present time only a few states have an organizational mechanism for integrating science and technology into the processes of state and local governments and the few states that have such mechanisms are not supporting activities necessary for a long-term accomplishment. A relevant federal program and an effective organizational mechanism in every state is essential to national progress.

(5) It is, therefore, proposed that a federal-state partnership be established, through an appropriate federal agency, to develop policy, provide counsel, and support:

(a) Block grants on the order of hundred thousand dollars ($100,000) per year for each state to science and technology agencies on a fifty-fifty matching funds basis.

(b) Project grants, which ultimately might total as much as a million dollars a year, per state, through the state science and technology agencies with guidelines to be established by the federal-state partnership.

Appendix II

Quotes From National Leaders

BACKGROUND

The state and role of applied science and technology in the nation, in individual states, and in the university has been scrutinized recently by various committees, conferences, and articles. Here are excerpted quotations taken from the records of some of these, as pertinent background to the present proposal.

Dr. Donald F. Hornig, special assistant to the President for science and technology:[1] "It is commonly recognized that the economic level of the state or community depends on the technological level of its industry or agriculture.

"It is generally recognized that new technological input is one of the major ingredients of economic advance, and it is becoming recognized that technological expertise, properly used, and social science expertise, properly used, are important ingredients in approaching, if not solving, some of our deep-seated social problems."

Dr. Harvey Brooks, dean of engineering and applied physics, Harvard University:[2] "When the Government supports applied research in an environment that is not organizationally coupled to an end-use, it is likely to stray from the mark, and this becomes more of a hazard the closer the research is to application."

"Historically the universities have been the major centers of applied research in both agriculture and medicine, although in both these cases a large corollary development activity has also grown up in industry. The university research activity has been well coupled to the operational use of the results."

Dr. J. Herbert Hollomon, president, University of Oklahoma:[3] "The concern of the Congress and the people in this country is now beginning to be what happens in Cleveland or Harlem or in Columbus or Chicago or Watts. * * * The problems of this country are essentially local problems. The initiative and the brilliance must be taken not from a small group of people brought together in Washington to attack a national problem, but through small groups of people brought together locally to take the initiative to do those things that are necessary to the survival of our system * * *"

"We need to recognize that the technology that is going to deal with the problems of crime, education, medical services, or urban blight has to be supported locally. Then, if there is additional federal money for general purposes, it can be attracted only by beginning with local support."

Hornig:[4] "The federal governments funds in excess of eighty percent of the university research, and it supports graduate school scholarships and research assistantships for something like a third of all graduate students. I believe this involvement will grow in the future. *Nevertheless, it is fundamentally a state responsibility to support universities, develop their quality, and make them relevant to the needs and problems of the state.*"

"What is germane to governments at all levels is that science applications are either part of or relevant to almost everything we do in the modern world. In putting science at the service of society there are different tasks for different people. Research and development, for example, are only effective when they are done in the right relation to the user. I don't believe they can effectively be done in the abstract."

"If a truly constructive state-federal partnership is to be our future pattern, as I believe it must, there is going to be a critical need to have people at the state and local level with adequate responsibility and authority and knowledge to get things done. *There can be no effective communication unless there is someone talking at both ends of the communication channel.*"

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[1] Proceedings, NSF–SINB Conference on Science, Technology, and State Government, Louisville, Kentucky, September 19–20, 1968, pp. 188–189.

[2] Applied Science and Technological Progress, National Academy of Sciences Report to the Committee of Science and Astronautics, U.S. House of Representatives, June, 1967, p. 32 and p. 34.

[3] Ref. 1, p. 133 and p. 134.

[4] Ref. 1, p. 190, 191, 193.

Dr. Don E. Kash, associate professor of political science, Purdue University:[5] "Although Congressmen believe that the universities have the intellectual resources, they wonder if the universities can organize themselves to respond. One problem is the tradition of autonomy * * * another problem is that of the 'wall of separation between disciplines * * * Dr. Haworth has indicated, many of our most compelling problems will require experts from several universities. An interdisciplinary research program handled by a single university is unlikely to be able to tap the best combination of talents."

Hollomon:[6] "Every state needs an agency at the highest level of its government reporting to the governor, having to do with the applications of science and technology to the welfare of that state."

"This agency should have three functions: One is to see to it that science and technology and its beneficial effects can be brought to the affairs of the state and to make state governments and local governments more effective and more efficient, realizing the political hazards and difficulties along the way. It should, secondly, examine what sort of economic, social and industrial development should take place in the state and recommend to the governor and to the legislature technological programs that will support that state's growth, not what programs will support the national effort. It should also be concerned with the nature of the resources of the state which would permit it in the future to have a more effective state and local government and a more effective source of trained and technical manpower; that is to say, it should give guidance to the colleges and universities and high schools of the state with respect to the development of technology."

"I believe that every state legislature needs an oversight committee, or, if you will, a substantive committee that deals with the question of how and when and if technology and science should be applied to the problems of the state and region and under what conditions. It should authorize the expenditures of money for these purposes."

"I believe that every state government should have an executive officer reporting to the governor, appointed from outside of the government as do the executive offices of the Federal establishment. I was such an officer for six years as was Jerry Weisner and Don Hornig, whom we will hear today. This officer would bring to the state government the differing point of view of private people to the affairs in the state."

Hornig:[7] "I would propose for my successor, and I think it is a most important thing, that he:

> "First, initiate a set of conferences with the states to begin to develop a working relationship;
>
> "Second, establish within the Office of Science and Technology at least one man, and possibly a full staff, to maintain constant and continuing contacts between the Office of Science and Technology and its mechanisms—the Federal Council for Science and Technology and the President's Science Advisory Committee—and the corresponding elements in the states."

"This would provide for the mutual flow of information, and also in the longer term would give hope of developing a more coherent system of action."

Appendix III

Remarks on Proposed Policy

It is necessary, of course, that state and federal programs bringing scientific resources to bear on urban and environmental problems be coordinated to reinforce one another.

The states are confronted with problems of such magnitude that it is imperative that all Federal agencies render such assistance as may be required to strengthen state scientific institutions. It is no longer defensible to conduct the bulk of scientific research solely without consideration of state and local interests to meet Federal interests and requirements.

NSF support of the programs proposed here may be highly advantageous since—

(*a*) The NSF state-science program is unique in Federal Government in that it can support development of state and local strength.

[5] Science, *160*, 1313 (1968).
[6] Ref. 1, pp. 133–134.
[7] Ref. 1, p. 195.

(b) NSF's strong ties to the academic and scientific communities enable it to mount a state assistance program more effectively than other Federal agencies;

(c) An NSF program, can span a wider range of interests than mission-oriented programs of other Federal agencies. Frequently, state problems are not easily fitted within the terms of Federal agency mission responsibilities;

(d) It is often easier for NSF to fund programs jointly with other agencies than it is for operational agencies to collaborate;

(e) NSF relationships with states are mandatory if NSF is to program effectively its new "applied research" authority in social problem areas.

The opportunity to bring scientific knowledge and technological skills in diverse disciplines into new innovative approaches which can contribute to the solutions of our urban and environmental problems amounts to advancing new concepts of an engineering nature.

The functions of the university, government, and industry in finding effective routes to the use of new knowledge to solve our urban and environmental problems and the nature of the partnership among those which may be effective are, perhaps, illustrated by consideration of the several steps involved in new technological developments.

NEW KNOWLEDGE—NEW TECHNOLOGY AND CONCEPTS—NEW SERVICE TO HUMAN NEEDS

These, and the relative involvement we may expect from elements of society may be visualized as follows—

		Relative involvement		
			Client-sponsors	
State	State of development of new solutions	University	Community	Industry
1	Definition of problems	***	***	*
2	Innovative conceptual solutions	***	***	**
3	Explore and develop basic features of solutions	***	*	**
4	Feasibility demonstration	*	**	**
5	Development		***	***
6	Installation		***	***
7	Use		***	***

Note: The times demand major attention in the immediate future to stages 1, 2, and 3. What are the new innovative engineering-social concepts for marshaling our resources to provide more efficient and effective health care, environmental control, urban regeneration, transportation and the like? We must advance such new concepts, examine them critically and perfect them, and move to demonstration projects quickly. This requires intellectual leadership with university, industry, and governmental leaders and close collaboration among innovator, user, and ultimate supplier.

CORNELL UNIVERSITY,
CENTER FOR RADIOPHYSICS AND SPACE RESEARCH,
Ithaca, N.Y., June 6, 1969.

Senator EDWARD M. KENNEDY,
Senator Office Building,
Washington, D.C.

DEAR SENATOR KENNEDY: As you know, we have been deeply concerned with the possibility that the project to improve the large radio telescope at Arecibo, Puerto Rico may be deferred. It has been suggested that we provide a summary of the situation surrounding this project as an aid to your subcommittee in considering it. I enclose such a summary which was prepared today.

Sincerely yours,

F. D. DRAKE, *Associate Director.*

Enclosure.

INFORMATION ON THE PROJECT TO IMPROVE GREATLY THE 1000-FOOT RADIO TELESCOPE AT ARECIBO, PUERTO RICO, AND RELATED CONGRESSIONAL ACTION

The 1000-foot radio telescope at Arecibo, Puerto Rico, is the world's largest radio telescope. It is operated by Cornell University with support by the National Science Foundation and the Advanced Research Projects Agency, and is used for research in ionospheric physics, radar astronomy, and radio astronomy by scientists from all over the U.S. and some foreign institutions. It has had an outstanding record of scientific achievements in its five years of operation.

It is of very great importance scientifically and nationally to improve the telescope reflector surface so as to enable the reception of much shorter radio wavelengths than at present. This would permit the study of many radio spectral lines of great importance, but now unobservable. These include some of the newly-discovered lines of organic and perhaps biologically important molecules recently discovered in interstellar space. It would permit the measurement of polarizations, intensities, and positions in the sky of tens of thousands of cosmic radio sources. Of very great potential would be the ability to produce a radar picture of the surface of the planet Venus with a resolution of about one mile, equal in quality to the best photographs of the moon taken from earth based telescopes. This will not be possible with any other instrument, and would be of prime importance scientifically and to the space program. This latter accomplishment is possible in 1972, and then not again until 1975. The improved telescope would have a radar sensitivity some 500 times greater than any other existing radar telescope.

Other major instruments which could achieve these goals could not be constructed in less than five years. The proposed Arecibo upgrading will take two years. In Germany, a 330-foot fully steerable radio telescope with short wavelength capability is far along towards completion, and will probably go into full operation in the middle of 1970. The completion of this German telescope will to a large extent relegate the U.S. to second class status in radio astronomy, a situation which can be reversed quickly only through the Arecibo upgrading.

It has been amply demonstrated that the upgrading of the Arecibo telescope is feasible at relatively modest cost. In 1966 it was recognized that the basic mechanical structure of the antenna was suitable for operation at much shorter radio wavelengths, but that telescope performance was limited by imperfections in the reflector surface. With support from the National Science Foundation, a study has been completed of a new reflector surface by the Rohr Corporation, the most experienced company in the world in large radio telescope construction. This study has shown that a new reflector surface can be constructed with a quality matching that of the rest of the structure, and allowing short wavelength operation. The new surface would be built in quite a straightforward way, requiring no new concepts or untried engineering principles and techniques. Full operation of the telescope would be maintained throughout the upgrading.

The cost of the upgraded surface would be $3.8 million, including $3.5 million to go to a firm for the upgrading, and the remainder to be used for management and contingencies. The expenditure of this sum would provide full radio astronomy capability at the short wavelengths. To achieve the full radar capability, including the Venus mapping capability, an additional sum of about $2.5 million is required. This would be used primarily to procure a short wavelength radar transmitter of very high power, with the rest being used for other telescope improvements.

The Arecibo upgrading was given the highest priority by the Dicke Committee, a special committee of eminent physicists, electronics engineers, and radio astronomers, which was convened in 1967 by the NSF to review needs in American radio astronomy. The NSF has requested funding of the project in fiscal 1970, and has also placed great emphasis on the project.

Congressional action to date has consisted of a recommendation that the project be deferred by the House Subcommittee on Science, Research, and Development, whose chairman is Rep. Emilio Q. Daddario. The reasons for this deferral are in no way related to the great scientific merits of the project, but rather derive from the fact that the sponsorship of the Arecibo Observatory is being transferred from ARPA to NSF as of October 1, 1969, and there is a critical attitude in the Daddario subcommittee towards transfers of this nature. Deferral of the Arecibo upgrading is an expression of the Committee's desire that an improved governmental procedure for such transfers be developed.

The NSF authorization, including the Arecibo upgrading, is still being considered by the Senate Subcommittee dealing with the NSF, which is headed by Senator Edward M. Kennedy. Every effort is being made, particularly by the NSF, to convince this subcommittee that restoration of the funds for upgrading is desirable.

Deferral of this funding will delay by at least a year the completion of the upgraded telescope. This will result in the loss of important scientific activities, and the prolongation by at least a year of second-class status by the U.S. in some of the most significant lines of scientific inquiry. Very likely the present losses of scientific personnel, due to the existing austerity situation, will be

worsened by a further demonstration of lack of support for U.S. science. The opportunity to map Venus in 1972 will be lost.

(Prepared by F. D. Drake, Associate Director, Center for Radiophysics and Space Research and Chairman, Astronomy Department.)

NORTHEASTERN UNIVERSITY,
Boston, Mass., May 8, 1969.

Hon. EDWARD M. KENNEDY,
Senator from Massachusetts,
U.S. Senate, Washington, D.C.

MY DEAR SENATOR: It has been brought to my attention as Chairman of the Governor's Advisory Committee on Science and Technology in the Commonwealth of Massachusetts that the Subcommittee on the National Science Foundation of the Committee on Labor and Public Welfare is meeting to hear testimony relative to the funding of joint federal-state programs involving the application of science and technology to the solution of today's critical social problems.

The Governor's Advisory Committee on Science and Technology, now in the fourth year of its existence, has as its major present project the establishment of a Massachusetts Research Foundation. This Foundation would monitor research and advanced development projects such as those that are the central topic of your hearings. The Foundation is the subject of House Bill Forty-six which is currently before the House Committee on Ways and Means of the General Court of Massachusetts.

The major obstacle which we now face is adequate funding for our projects. State funds available to us are limited due to the heavy tax burden already imposed upon our citizens. We fear that House Bill Forty-six will fail of enactment unless federal funds are made available to share in the costs of operating our program. The provisions within the proposed N.S.F. budget would provide this much-needed support.

We feel strongly that effective gains against the problems of pollution, housing, transportation, health, etc. are going to be made only with the kind of all-out attack which requires a lot of money. Since these are national problems, as well as local and regional ones, it is reasonable to expect that the federal government would contribute substantially to the total cost of their solution. Also, it seems evident that federal support would insure that developments founded in one state would be shared with the other states to the economic betterment of the whole nation.

In summary, the Governor's Advisory Committee on Science and Technology of the Commonwealth of Massachusetts with great enthusiasm wishes to add its support to that of those favoring the proposed legislative action whereby the National Science Foundation, or any similar federal agency, is empowered to contribute to the total costs of operating state research and development programs in the public sector interest area. Please feel free to call on us for any help which you feel we may be able to give to your program.

Sincerely yours,

MARTIN W. ESSIGMANN,
Dean of Research, and Chairman,
Governor's Advisory Committee on Science and Technology.

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., February 27, 1969.

Hon. RALPH YARBOROUGH,
Chairman, Committee on Labor and Public Welfare,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN. In Senate Report No. 1137, 90th Congress, 2nd Session, on May 21, 1968, the Committee on Labor and Public Welfare requested (on page 20):

" . . . the National Science Foundation to give high priority to equalize through administrative action the terms and amounts of individual and institutional support programs similar to programs administered by the U.S. Office of Education and other Federal agencies. If this equalization cannot be accomplished by the administrative means suggested within 6 months of the date of this

report, then the committee requests the Foundation to submit to this committee a report on the reasons therefor together with appropriate legislative recommendations to accomplish the equalization."

By letter of November 22, 1968 (copy attached), I reported to your committee that progress was being made in those areas of concern to the Committee, and I indicated that I would provide you with a more detailed report in the near future. At that time, it was pointed out that for some time the Committee on Academic Science and Engineering of the Federal Council on Science and Technology had been working to promote greater uniformity in policies, procedures, and forms for various Federal Government programs supporting the construction of academic facilities.

HEW and NSF Programs to Support Construction of Academic Facilities. In my letter of November 22, 1968, it was stated, "With respect to HEW and NSF defferences in the Federal contribution available through programs to support construction of academic facilities, the recent action of the Congress in raising the maximum Federal contribution of the Office of Education's Academic Facilities Programs from 33⅓ percent to 50 percent equalizes the matching contribution of the various academic facilities programs. In practice, the majority of such grants are negotiated so that the Federal share is considerably less than 50 percent. Some of these programs have authority by law to go above the 50 percent level in specific instances, but since these exceptions are expected to be minimal in number, this is not considered a significant difference."

Representatives of the Foundation and of the Department of Health, Education, and Welfare have been meeting in an attempt to resolve other major differences among their various comparable academic facilities construction programs. As a result of these meetings, the Foundation and the Department of Health, Education, and Welfare have agreed to equalize the following procedures and allowances:

1. Equipment.—Equipment previously has been defined differently among the several programs as fixed, movable, program equipment, furnishings, apparatus, etc. The policy which both agencies have adopted now will minimize the importance of categorizing equipment by providing that any equipment is an allowable project cost provided it is necessary for the functioning of the building and consistent with the purposes of the program under which the application was filed.

2. Space.—The program staffs of each agency formerly had determined the kinds of space allowable for financial participation on an individul program-by-program basis. This resulted in disparities between programs with respect to support for space for postdoctoral students, classrooms, graduate laboratories, and office space. The policy now adopted is to allow that space which is necessary to make the building functional and which is consistent with the program mission.

3. Parking space.—Under some programs of both agencies funds have been allotted for building construction without provision for adequate parking spaces for buildings. Parking space often is necessary and at times vital for the effective use of buildings, particularly in urban areas. Further, local codes often require provision for adequate parking for the users of buildings. Therefore, in computations of the amount or portion of the Federal grant, costs for adequate parking space will be allowed.

4. Works of art.—In order to encourage high standards of design and to enhance the aesthetic value of buildings, costs for works or art now will be allowed by both HEW and NSF up to one percent of the grant funds.

5. Land or land and buildings.—HEW and NSF have agreed to allow costs for acquisition of necessary new land or land and buildings. We understand that necessary legislative changes will be requested by HEW for appropriate programs.

6. Off-site improvements.—Although off-site utility line, walkways, and other improvements are at times necessary for the functioning of buildings, some HEW programs are prohibited by statute from allowing the cost for these improvements in computing the amount of the grant. NSF has heretofore considered these costs eligible and we understand that legislative changes will be requested by HEW for affected programs so that necessary off-site improvements will be uniformly allowable.

Progress had been made toward developing a uniform proposal format (or form) suitable for comparable academic facilities programs. The CASE Task Force on Facilities recommended such a form in December 1966. However, the desire of HEW to bring all of its 28 construction programs under one application form necessitated a drastic change that made the form no longer advantageous

for use by the Foundation's graduate facilities program. While the advantages of having one form for all of its 28 construction programs outweighs the disadvantages for HEW, the same does not hold true for the comparable program of the NSF, since no accommodations have to be made by NSF for requesting information for as great a diversity of programs, including non-academic programs, as is the case for HEW. However, to obtain as much uniformity as possible, NSF and HEW are developing uniform procedures for requesting certain information (e.g., budget information).

HEW and NSF programs for predoctoral student support

In my letter of November 22, 1968, I indicated that the Federal Interagency Committee on Education (FICE) was then engaged in a study of predoctoral student stipends and allowances. The study was reviewed and accepted by FICE on December 18, 1968, and I am attaching a copy for your information. It should be noted that FICE, while agreeing generally to the recommendations of the study concluded that for reasons related to the budget and the budget cycle the adoption of changes in stipends and allowances appearing in the summary on page V of the report should be postponed for at least a year.

Implementation of the FICE recommendations—leading to greater consistency in the payment of stipends and allowances—must be given further consideration in the development of the budgetary and legislative proposals of the Administration. Further discussion and negotiation by FICE may also result in modification of the current recommendations as additional information becomes available or as conditions change.

I should also point out that even without the changes recommended by FICE, there is already a high degree of consistency between the NSF predoctoral programs and related programs of the Department of Health, Education, and Welfare with regard to stipends and allowances. This has been true for many years particularly in the case of the predoctoral programs of the National Institutes of Health and the Foundation where a determined effort has been made to follow consistent policies and practices. Lack of standard policies and practices only arose with the advent of newer programs such as the NDEA fellowships (where differing stipends were written into the legislation) and such as the NASA fellowships.

Please be assured, Mr. Chairman, that the National Science Foundation will continue to work actively with the Department of Health, Education, and Welfare and with other Federal agencies to achieve the maximum uniformity, consistent with the purposes of the various programs, in the "terms and amounts" of Federal grants among comparable programs for student support and for academic facilities construction.

Sincerely yours,

LELAND J. HAWORTH, *Director.*

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., November 22, 1968.

Hon. LISTER HILL,
Chairman, Committee on Labor and Public Welfare,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: In Senate Report No. 1137, 90th Congress, 2nd Session, on May 21, 1968, the Committee on Labor and Public Welfare requested (on page 20):

". . . the National Science Foundation to give high priority to equalize through administrative action the terms and amounts of individual and institutional support programs similar to programs administered by the U.S. Office of Education and other Federal agencies. If this equalization cannot be accomplished by the administrative means suggested within 6 months of the date of this report, then the committee requests the Foundaton to submit to this committee a report on the reasons herefor together with appropriate legislative recommendations to accomplish the equalization."

I wish to report to you that progress is being made in those areas of concern to the Committee.

Certain problems in the administration of Federal grant programs for the support of construction of academic facilities have concerned the Federal agencies for some time. The Committee on Academic Science and Engineering (CASE) of the Federal Council on Science and Technology (FCST), formed a CASE Task Force on Facilities (composed of agency facility program officers) in February 1966 to devise means for promoting greater uniformity in policies,

procedures, and forms for the various Federal government programs supporting the construction of academic fcilities. Susequently, early in 1967, after a report from the Task Force had been considered by CASE and the Federal Council, the Council established a CASE Subcommittee on Facilities, composed of agency representatives. The Subcommittee on Facilities submitted to the FCST in June 1968 an interim report, "Recommendation for Improved Administration of Federal Grant and Loan Programs for Construction of Campus Facilities," and the report was accepted and became effective for member agencies of the Council, including HEW and NSF. The "Recommendation" covered the following subjects: Single Agency Management, Joint Site Visits, Lump Sum Contracts and Competitive Bidding, Public Advertising in Selection of Bidders, Uniform Procedures for Treating Alternate Bids, Prorating Costs Among Participating Agencies, Uniform Language in Application of Requirements for Equal Employment Opportunities and Labor Standards, Contract Modifications, and Contingency Funds. The CASE Subcommittee was not assigned responsibility for the question of proportionate contributions of agencies as related to grantees since it was felt to be beyond the purview of CASE. The interim report did not cover items eligible for inclusion as between HEW and NSF, as discussed below. The subcommittee is continuing its work on this and oher unresolved issues.

With respect to HEW and NSF differences in the Federal contribution available through programs to support construction of academic facilities, the recent action of the Congress in raising the maximum Federal contribution of the Office of Education's Academic Facilities Programs from 33⅓ percent to 50 percent equalizes the matching contribution of the various academic facilities programs. In practice, the majority of such grants are negotiated so that the Federal share is considerably less than 50 percent. Some of these programs have authority by law to go above the 50 percent level in specific instances, but since these exceptions are expected to be minimal in number, this is not considered a significant difference.

Representatives of the Foundation and of the Department of Health, Education and Welfare have been making what we consider to be significant progress in reducing remaining differences between the academic construction support programs of the Foundation and component agencies of the HEW.

The Student Support Study Group of the Federal Interagency Committee on Education (FICE) has undertaken a Study of Predoctoral Student Support. A report which recommends both administrative and legislative changes to minimize differences between student support programs of the several agencies will be considered by FICE in the immediate future. I am hopeful that from this will come very meaningful progress and a basis for recommendations to your Committee.

Work is continuing on these matters, and I expect to be able to send to the Committee in the early weeks of the next Session, (and before any authorization hearings) a substantive report showing the specific changes being made, and recommending whatever legislative actions appear necessary to reduce further any remaining differences which may be considered desirable to eliminate or change.

If the Committee or the staff wishes to discuss this matter, I suggest that arrangements be made with Theodore W. Wirths, Congressional Liaison Officer for the Foundation, at code 183 extension 7761.

With best regards.

Sincerely yours,

LELAND J. HAWORTH, *Director.*

[From Science Magazine, May 23, 1969]

CONGRESS MEETS SCIENCE: THE APPROPRIATIONS PROCESS

Although legislators question the purposes and management of science programs, they play a supportive role

(By Michael D. Reagan [1])

The federal government's role as patron of science has been discussed and documented at some length in recent years.[2] The emphasis in most writings,

[1] The author is professor of political science at the University of California, Riverside 92502.

[2] In addition to articles in *Science*, other leading studies are: A. H. Dupree, *Science in the Federal Government* (Harvard Univ. Press. Cambridge. Mass., 1957); D. K. Price. *Government and Science* (New York Univ. Press, New York, 1954); ———. *The Scientific Estate* (Harvard Univ. Press, Cambridge, Mass., 1965); R. Gilpin and C. Wright, *Scientists and National Policy-Making* (Columbia Univ. Press, New York, 1964); and D. S. Greenberg, *The Politics of Pure Science* (New American Library, New York, 1968).

however, has been upon activities of departments and agencies of the executive branch. The congressional role has been little examined. This article explores one major type of confrontation between Congress and science: the legislature's overseeing of science agency programs as it is accomplished through the appropriations process.

The appropriations process is a crucial point of contact, and not only because that's where the money is. It is also the most frequent, continuing means by which the legislators attempt to exercise control over the coordinate executive branch. Congressional oversight, so-called (the function of ensuring that executive agencies fulfill their statutory mandates effectively and efficiently), is also performed by the substantive committees (the ones on agriculure, commerce, and so forth), by the committees on government operations and by ad hoc special investigations; but the appropriations process is the only vehicle of oversight that operates every year with respect to every agency.

Appropriations work is done primarily by specialized subcommittees, each handling a paricular department or functional area. There is no science budget as such, just as there is no single agency engaged in science. To examine the Congress-science relationship in the appropriations arena is therefore to look at particular subcommittees dealing with particular agencies. I shall focus on the National Science Foundation (NSF) and three science-oriented bureaus in non-science departments: the Geological Survey (GS) in the Department of the Interior, Agricultural Research Service (ARS) in the Department of Agriculture, and the National Bureau of Standards (NBS) in the Department of Commerce. In NSF, science stands "on its own" as it were; in the others, Congress sees science as embedded in the extrascientific missions of the respective departments. Covering both enables us to see whether science per se is differently handled or fares worse or better than science given the "protective coloration" of some other social mission. Each of the three science bureaus examined is the largest research-oriented component of its respective department, and each performs basic as well as applied research. Approximately half of the ARS and NBS research budgets go into basic research, taking fiscal 1967 as an example, and in GS the proportion devoted to basic research is about three-fourths. These budgetary allocations are sufficiently large so that any particular congressional biases regarding basic research would certainly become apparent in the process of making appropriations.

The format of appropriations is designed so that each major component of a department (the generic name for these components is bureau) is considered as a discrete unit. Each receives its own hearing, those covered here generally being allocated from half a day to a full day of discussion. The findings reported here are based on hearings for the period of fiscal years 1962–68.

GEOLOGICAL SURVEY

During the years covered, the appropriation for the Geological Survey increased from $50 million to $85 million. The work of the Survey was changing rapidly, with diverse new programs being added in the mapping of rare mineral and metal deposits, earthquake studies, water studies, oceanography, and the remote sensing of minerals. The traditional topographic mapping, despite its continuing importance in the agency's overall program, elicited relatively few comments because it was a long-accepted activity. Legislators would simply ask how many states remained to be covered and what uses were made of the maps as they became available. As is typical in appropriations hearings, the agency head briefly described each of his programs and the legislators asked for justifications of the increased funds which were sought. In addition to questions designed to give the agency an opportunity to present its financial justifications, congressmen often asked about possible ways of cutting costs (for example, whether the system used for distribution of maps and reports could be simplified), about the efficiency of the bureau's administrative organization, and about the rate of progress on various previously funded programs. One favorite question concerned the extent of interagency duplication in mapping activities. When a new Institute of Water Research was proposed it was held up pending a study of duplication and coordination in federal water research generally. Even among new programs, there was, on the whole. little substantive questioning, little attempt by the congressmen to substitute their judgment for that of the bureaucrats regarding what constituted desirable or needed new programs. Among the exceptions to this general acceptance of agency programs was a postponement of funding for a proposed national atlas and a definitely hostile attitude toward

participation in the International Hydrological Decade. One congressman said at the fiscal 1968 hearings, "With the urgent water problems we have in this country, the committee is naturally very dubious about any extension of our water investigation to an international basis until we have made greater progress on the problems affecting our own nation."

In general, it was not the scientific content of programs that the legislators were interested in so much as what might be called management questions. For example, each year there were questions about the status of federal-state cooperative programs, with some concern being expressed as to whether the states were paying their share; about royalty income from mineral leases; and about royalty accounting procedures. Even when they were considering cuts in the budget, the legislators asked the administrators for their views of program priorities.

There were few differences between the House and Senate hearings, the latter being generally much briefer (as is the case with all agencies) because they usually covered only programs that had been cut by the House, rather than the entire work of the agency. There was some tendency among senators from western states to ask constituency-oriented questions regarding minerals development and water work. A senator from Alaska was particularly interested in the earthquake prediction problem; senators from Arizona and Nevada, with the study of water evaporation losses.

In summary, one could say that the appropriations committee members used their questioning to deal with matters of program purpose, program usefulness, and management effectiveness—matters in which they could reasonably assert some competence—and did not to any significant degree interpose amateur judgments regarding the scientific substance of GS programs.

NATIONAL BUREAU OF STANDARDS

During the period examined here the National Bureau of Standards appropriation was handled by a subcommittee that dealt with the Depatments of State, Justice, and Commerce. With a research appropriation varying between $24 and $32 million, NBS represented but a minute proportion of this subcommittee's appropriation bill. However, it did receive from one-half a day to a full day of hearing time each year in which to present and justify its budget request. The hearings were marked by an almost total absence of substantive discussion of NBS scientific programs. The subcommittee chairman, Representative John J. Rooney (D–N.Y.), continually expressed a general distrust of needs for expansion of activities and on more than one occasion accused Allen V. Astin, director of the Bureau, of having "no limits" regarding what he would seek. Yet Rooney did not attack the substance of programs directly, with one exception. This was a proposed fire technology program in the fiscal 1964 budget. On the basis of objections from private industry which he had received, Rooney attacked this proposed new program as a duplication of private enterprise, and the subcommittee turned it down—in such certain terms that NBS did not even try to appeal it to the Senate committee.

The bulk of questioning concerned construction costs of a group of new buildings that NBS was in process of putting up, and whether the states and industry should pay for a larger share of NBS services. One of the new NBS programs in this period was to provide new sets of weights and measures of standards to the states (a program which is currently being implemented) and the subcommittee expressed the thought that the state contribution to the program should be greater than that planned by the bureau. The development of a Standard Data Reference System was an important program of NBS during the period covered and justifications for the program stressed its value to technological development in private industry. The subcommittee was frequently critical because it felt that NBS was doing work that private industry should pay for. Though it was concerned with who should pay the cost, the subcommittee did not question the utility claimed for the Standard Data Reference System. Rooney was in general skeptical of the value of programs described, without going into them in depth. Typical of his questioning was a desire to know how North Carolina textile mills had been helped by a recently inaugurated textile research program. He was not satisfied when he was told about the dissemination of technical information that had been begun under this program. He apparently wanted more immediate and dramatic results.

Since the House committee made substantial cuts in the budget requests each year, the Senate hearings were largely concerned with the requests for restoration of funds cut. Senator McClellan questioned just what was to be done under

the Standard Data Reference Program and sought estimates of the future size and length of time of the project. He seemed to accept without question assertions regarding the utility of the program to the nation's technology. In another instance, McClellan questioned proposed research on building-structure performance characteristics which was intended to make possible lower housing costs. He expressed doubt regarding the value of such research, thinking it unnecessary and probably ineffective, yet he seemed also to be sincerely seeking a convincing explanation.

In neither the House nor the Senate hearings did the legislators appear ready to enter into technical discussion of bureau programs. The kind of work that NBS is engaged in is basic to national science and technology, but often quite indirect in its application. Hence NBS programs, such as the Standard Data Reference System, do not easily lend themselves to legislative understanding or discussion in terms of end-product purposes. Perhaps this is one reason why this bureau fared less well than the others studied here in terms of its ability to gain a high percentage of its requested appropriation each year.

Despite the Appropriations Committee's willingness to interpose its judgments over those of the agency in regard to the amount of money needed, it did tend to defer to the agency regarding where cuts should be made. That is, it generally allowed NBS to decide where to absorb the cuts. One senator said in the fiscal 1963 hearings, "Of course, you know about the relative importance of these programs, and the Committee cannot know very much about that." In similar vein, Senator McClellan asked Astin to supply a priority list of items that NBS wanted restored from the House cut, so that the Senate could have expert advice on program importance in making its own judgement regarding how much of the cut to restore, if any.

AGRICULTURAL RESEARCH SERVICE

Nothing illustrates better the significance of congressional positions relative to science programs than the contrast between the National Bureau of Standards and the Agricultural Research Service. ARS has faced appropriation subcommittees whose chairmen and most of whose members have personal and constituency interests in the subject matter with which the agency deals. And even when its research is truly basic and scientifically esoteric, its purposes are nevertheless highly pragmatic and easy for the layman to understand. Under these circumstances, ARS can begin its budgetary testimony each year in a highly favorable environment. Also, the agency has been particularly astute (in the eyes of this observer, at least) in its mode of presentation of its case. Instead of the usual pattern of presentation in which the head of the agency summarizes all the programs, each division chief within ARS describes in some detail the work in progress in his particular jurisdiction. This practice makes for surefooted explanations and surefooted replies to legislative questions. It is standard strategy in appropriations hearings for an agency to try to emphasize its substantive programs and to keep the legislators from getting off onto such questions as the number of automoblies or paper clips use, the number of personnel in high pay grades, or the cost of construction of buildings used by the agency. ARS has been highly successful in pursuing this strategy—perhaps helped by the preexisting interest of the appropriations subcommittee members in the substantive programs of the agency.

The pattern in ARS hearings is that the witnesses first make statements regarding the problems and diseases toward which their research programs are directed and report on progress in finding solutions. Then the legislators ask questions of an information-seeking character demonstrating a semipopular understanding of technical programs and their practical objectives. Discussion proceeds not by research categories but by problem areas: the boll weevil, pear, decline, brucellosis, hog cholera, and the eradication of fire ants, for example. The committee members tend to focus their respective inquiries upon research related to the specific problems of their own areas. Thus a representative from Kentucky focuses on tobacco research while the boll weevil engages the attention of the representative from Mississippi. When elm tree disease was discussed, one legislater mention the loss of elms on his street in Washington, D.C.; another mentioned a town in his district with the slogan, "City of Beautiful Elms," and cited efforts being made there to control the disease. When a cotton insect laboratory was mentioned, the House committee chairman, Representative Whitten (D–Miss.), expressed pride in having helped to get it funded and asked that the records show the losses due to the boll weevil so as to help justify research expenditures in this connection. In contrast to scientific research in some other

areas, it is relatively easy for the legislators to understand the purposes of agricultural research and their questions are largely practical ones about practical problems.

Unlike NBS and GS, ARS has a very immediate, nationwide economic constituency and a nationwide network of research stations. These facts, combined with the subcommittee's ability to understand easily what the research programs are about, result in a more active committee participation in the shaping of agency programs. When ARS, acting in response to executive branch cutbacks, announced in its presentation of the fiscal 1967 budget that it was planning to eliminate a number of small research stations, Representative Whitten strongly protested and demanded that each specific reduction be justified. He spoke of a large volume of mail from constituents protesting the prospective eliminations. The Senate subcommittee instructed the Department of Agriculture that research reductions or eliminations of research stations would require justifications in budget presentation just as much as increases and new facilities. Even when they were serving on appropriations committees, congressmen are not always interested in financial reduction. In fiscal 1967, the House committee restored $5.4 million which, if eliminated, would have meant the reduction or termination of work at 94 research stations. The committee also restored $7.8 million for pest and disease control from cuts that ARS had suggested in eradication programs. The subcommittee commented in its report:

". . . with U.S. commitments in Vietnam and other parts of the world, it would be a serious mistake to agree to budget reductions which would weaken our highly efficient and extremely productive agricultural industry, which forms the base for domestic prosperity and plays a major role in our foreign policy."

Such comments are not atypical in the handling of agricultural research appropriations. This is one area in which the appropriations subcommittee tends to be "more royal than the king" in its determination to further the work of the administrative agency.

Within this pattern, it is not unusual for the agricultural appropriation subcommittees to specify research programs to which the committees attach greater importance than ARS does itself. For example, in fiscal 1967 the Senate committee added $2.6 million to the research budget beyond what ARS asked, in order to institute research on swamp fever (equine infectious anemia), blue comb disease of turkeys, and swine abscesses, and to accelerate research on the mechanical harvesting of dates and on insect identification. Such unbudgeted increases turkeys, and swine abscesses and to requests made by outside organizations. Although appropriations hearings do not generally include outside witnesses or even written submission from interest groups, agriculture is an exception. Each year numerous outside communications are received in support of particular research projects· These are reflected in the comments and demands of the appropriations committee members.

In short, ARS enjoys the unusual privilege in the appropriations process of having extremely strong legislative support and faith in the value of its programs. Congressmen who examine its requests identify with agriculture in a way that the congressmen working with the Geological Survey do not necessarily identify with map-making, or with the Bureau of Standards' engineering programs. On the other hand, ARS pays a price for this support in the form of more detailed intervention and second-guessing by the appropriation subcommittees than is directed toward the other bureaus where the legislators may not feel familiar with or particularly sympathetic toward the work of the agency. This lack of familiarity causes them to be more hesitant about intervening in program priority matters.

With an annual range of $77 to $150 million during the period under review, the budget for agricultural research is but a minute fraction of the total Department of Agriculture budget. Yet research activities receive a disproportionately high share of attention in appropriations hearings and reports. Although half of ARS research is classified as basic rather than applied in the statistics gathered by NSF each year, it is clear that the appropriations subcommittees consider all of it as applied in the sense that is directed toward practical problems, and that they view research as an integral, even an essential, component of the agricultural industry.

NATIONAL SCIENCE FOUNDATION

To see if congressional consideration of "unprotected" science differs from its examination of the mission-oriented research in the NBS, GS, and ARS budgets, one must turn to the appropriations hearings of the National Science

Foundation. Perhaps the most important finding about NSF appropriations hearings is that they are not open to the ridicule of research projects that some scientists may expect—or fear. Although I suspect that many scientists have an image of NSF that is shaped entirely by its support of individual faculty research proposals, the fact is that basic research support constitutes only half of the NSF budget. The other half consists of various programs of educational support, scientific information, and so forth. Such matters as overhead payments, teacher-training institutes, curriculum preparation projects, science information programs, fellowships, secondary-school science education, and instructional equipment receive much more questioning than basic research does. These educational programs and questions of science management are obviously much more within the range of legislative competence than are the technicalities of NSF research.

When basic research is discussed in the hearings, the questions are not about the substance of particular research grants, but rather about such matters as the average amount of money per grant, why the number of grants increases each year, interagency coordination in granting research funds, grant-making processes, and the geographic distribution of NSF research grants. The late Representative Albert Thomas (D–Texas), who headed the subcommittee dealing with NSF for 15 years, was perennially disturbed about what he considered the relatively narrow distribution of funds. In the fiscal 1964 hearings, for example, he asked why NSF gave research grants to only 540 colleges and universities when there were 1100 4-year institutions. And in the fiscal 1966 hearings he objected vehemently to what he considered the too narrow geographic distribution of NSF fellowships. Referring to states with low numbers of fellowship holders he said, "There is not that much difference in human nature, gentlemen. If you give these people the same opportunity, they will go places, too." These comments by the legislator closest to NSF are significant, for they represent an image of NSF widely shared by Thomas' colleagues. It is an image which focuses upon research grants and fellowships as aid to education exclusively, without regard to their function as a stimulus to the production of the best new knowledge. In this regard, the concept of NSF held by the legislators is in opposition to that held by scientists, who tend to evaluate NSF entirely in terms of the amount of money it expends for project research without regard for its functions in the improvement of science education and in the development of scientific manpower.

The one exception to the generalization that the appropriations committee does not question particular research grants occurs in the area of social science research support. Social science is more vulnerable to questioning because it is less protected than the natural sciences by technical language unfamiliar to the legislators. The questioning, when it occurs, is likely to be of a scoffing nature; for example. when a representative asks, "Tell us how it will promote the scientific life of our country to study the cultural evolution in peasant communities." (Social science research is likely to cause problems for NSF for a long time to come. In the 1968 Daddario amendments, social science was explicitly added to the list of scientific areas that NSF is mandated to support. Despite this, there is clearly a great deal of ambivalence in the legislative attitude toward social science research. On the whole, what Congress wants is social research of an applied and immediately practicable nature, while the social scientists themselves seek funds principally for the further scientific development of their disciplines in preparation for eventual better utilization. These two sets of expectations will not be easily or soon reconciled.)

Although individual research projects are not questioned, there does tend to be some questioning about the national research centers (such as Kitt Peak National Observatory and the National Center for Atmospheric Research) and the national research programs (such as the Weather Modification Program, the International Biological Program, and Ocean Sediment Setting Coring Program). These queries regard the scientific purposes, the state of construction of facilities, and progress in operation. Through the cuts it recommends, the appropriations committee sometimes does interject its own views regarding the relative importance or desirable rate of progress for these national research centers and programs. Otherwise, it leaves the distribution of research funds to the foundation, even when cutting the total amount appropriated. That is to say, no attempt is made to substitute legislative for foundation judgment on such matters as the amounts allocated respectively to physics, chemistry, and biology.

In areas other than research support, the legislators apparently feel freer to interpose their own judgments. Thus in 1962, the House Appropriations Committee reduced NSF's total request by approximately $20 million, but increased the funds for institutes for secondary school teachers by $5.4 million and directed NSF not to spend less on this than the total of $37 million appropriated. In fiscal 1966, also, the House set a minimum expenditure on secondary teacher institutes, a minimum above NSF's request, and also directed that none of the $50-million cut it made that year should be taken from the science development program (the so-called "centers of excellence" program). Except for such dictates, NSF is free to redistribute its appropriated funds more or less as it sees fit among various program categories. (Like every other executive agency, however, it would not exercise this prerogative very far without informally seeking the concurrence of the appropriations committees.) During the period covered, the most notable substitution of committee judgment for foundation judgment came, of course, on the matter of Project Mohole. Senator Allott used appropriations hearings for his major attacks on this program in 1962 and 1963, and Representative Evins (D–Tenn.) canceled it when he was subcommittee chairman in 1966. I do not think this episode can be fairly viewed as interference with scientific judgment, however, for the legislative action was basically the result of management problems with Mohole, rather than a questioning of its scientific merits. It is true that Evins apparently did not see great scientific value in the program, but it is also safe to say that he would not have brought about its elimination if there had not been prior criticism of its management.

The treatment of NSF in appropriations hearings, then, does not appear to differ in most respects from that accorded scientific bureaus which are contained in extrascientific departments. Congressional attention focuses more on questions of management and program aims than it does on scientific substance. There is, however, a difference in the congressional conception of the meaning of research.

By and large, the legisaltors regard research not as the search for new knowledge but as practical problem-solving—and the bureau chiefs encourage this view in their presentations. No distinction is made between basic and applied research in appropriations discussions. Rather, the legislators see research as useful or not useful. To them, all meaningful research is applied research, and departmental missions provide the orienting extrascientific focus for discussion.

Since they view research as a matter of problem-solving, congressmen face the mission-oriented bureaus with a generally favorable attitude—an attitude approaching a mystical faith—in the case of agricultural research. Only when it is performed by the NSF does research appear to be an esoteric activity. In that context, basic research does stand somewhat naked. Although it is not often able to cite commercial applications of the research it sponsors, NSF makes an attempt to convey some sense of the excitement of science and of the fundamental significance of the work it supports. The results of these efforts are not always all that the agency might wish. For example, when a physicist finished describing an experiment to test relativity theory, a congressman asked, "What difference does it make as regards life on earth. . . .?" The appropriations subcommittee chairman, who is fond of referring to himself and his colleagues as "practical men on this isde of the table," asked, "What is the payoff, what is the result?" No matter how often NSF officials make the point that undirected basic research underlies all applied efforts, their most effective arguments remain those which justify research by its contributions to graduate education and the development of scientific manpower.

APPROPRIATIONS RESULTS

The results of the appropriations process reveal that basic research as represented by the NSF budget fares about as well as the combinations of basic and applied research budgets of the other bureaus. There are two ways of measuring the relative success of an agency in the appropriations process.[3]

One is to determine the gap between the agency's estimate (its budget request) and the actual appropriation. Table 1 expresses this gap in the form of the appropriation as a percentage of the estimate. In this contest the Agricultural Research Service is clearly the winner. The final appropriation in each year was at least equal to the amount requested, and in most years, it was greater. One might see this situation as a reflection of the continued strength of agricultural representation in the Congress—certainly in the agricultural appropriations

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[3] See R. F. Fenno, Jr., *The Power of the Purse: Appropriations Politics in Congress* (Little, Brown, Boston, 1966).

committees. The percentage of success of the other agencies is more normal. Note that NSF's average would look better if fiscal 1964 were omitted. A low percentage in that year reflects an unsuccessful, though brave, attempt on the part of NSF to increase its budget from $322.5 to $589 million in a single year. Congress, which tends to act incrementally, rarely approves jumps of that magnitude. This was not just wishful thinking on the part of the foundation, however, for an exception to the incremental rule had occurred between 1961 and 1962 when the NSF appropriation jumped by 50 percent. But, as pointed out, that is rare. At any rate, it is clear that the foundation did reasonably well by this measure.

TABLE 1.—APPROPRIATIONS AS PERCENTAGE OF ESTIMATES

Fiscal year	Percentage appropriated				Fiscal year	Percentage appropriated			
	NSF	GS	NBS[1]	ARS[2]		NSF	GS	NBS[1]	ARS[2]
1963	89	98	90	113	1967	91	99	95	112
1964	60	94	83	118	1968	94	97	82	100
1965	86	98	90	102					
1966	91	98	82	100	Average	85	97	87	108

[1] Research appropriation only. Excludes plant and facilities construction.
[2] Research appropriation only. Excludes disease and pest control and most inspection programs.

How close the final appropriation is to the original request, however, is largely a measure of an agency's ability to gauge congressional sentiment that year. The percentage increase of each agency's funds over the previous year is presented in Table 2. On this score NSF looks even better. It is outdone only by ARS, and that was because Congress gave ARS more than it requested each year. The average figures conceal cycles of congressional generosity and economy which are clearly evident in the annual data. The most recent fiscal years have not been particularly generous ones throughout the federal government, thanks to the Vietnam war. While it would be difficult to assign reasons, it appears that basic research as represented by the National Science Foundation is easier to justify legislatively than the presumably more technological applied work of the National Bureau of Standards. Or there may be other explanations: the adequacy of agency presentations, the mood of different subcommittee chairmen, or the fact that NBS lacks as definable a constituency as that which the universities comprise for NSF. Whatever the reasons, it is clear that academic scientists would be unjustified in feeling that "their" agency was in any way singled out for unfavorable treatment in the appropriations process. Over the total period of fiscal years 1962–68. NSF's appropriation increased 88 percent, Geological Survey's by 72 percent. NBS by 29 percent. and ARS by 97 percent. Many other federal bureaus and agencies would be happy to show a percentage increase in the same period of time equal to that of NSF.

TABLE 2.—ANNUAL INCREASE (OR DECREASE) IN APPROPRIATION

Fiscal year	Increase or decrease (percent)				Fiscal year	Increase or decrease (percent)			
	NSF	GS	NSB	ARS		NSF	GS	NBS	ARS
1963	20	16	14	15	1967	0	12	3	5
1964	10	10	4	21	1968	3	7	2	2
1965	22	6	10	12					
1966	14	5	−6	18	Average	11	9	5	12

This paper has made a limited examination of congressional appropriations process regarding scientific programs with a sizable component of basic research. Within its limits, however, it does permit some tentative conclusions about the Congress-science relationship—conclusions that are more auspicious for science than scientists might have expected. These may perhaps best be expressed negatively. First, appropriations committees do not, by and large, interject themselves into the substance of scientific research. They take this as a fact and concern themselves with the purposes and management of programs. Second, the legislators do not distinguish between basic and applied research and therefore cannot be said to single out basic research when looking for areas in which to make appropriations cuts. The classification of research into basic and applied may

be a distinction close to the hearts of scientists—at least the basic scientists—but it is not salient to the legislators. They look a programs and their purposes as useful or not useful in terms of social objectives and make their judgments accordingly. Third, we find that one cannot generalize that research bureaus protected by extrascientific missions are any better or worse off in the appropriations struggle than is the National Science Foundation which stands on its own as an independent agency. On the basis of my studies, I think it not too great an overstatement to suggest that Congress appreciates science and its accomplishments for legislative purposes somewhat better than many scientists seem to appreciate Congress.

(Excerpt from Basic Research and National Goals, a Report to the Committee on Science and Astronautics, U.S. House of Representatives by the National Academy of Sciences)

SUMMARY

To summarize 15 separately written essays on issues as complex as those raised by the House committee might seem at first sight to be an insuperable task. The task is made easier, however, because each paper was discussed and criticized extensively by the entire ad hoc panel. Although no author was compelled to respond to the criticism of his paper, most of the authors did, on rethinking, modify at least some of their original views, and to this extent there emerged many elements of a common position. This is not to say that all the authors agreed, even on some of the central questions; for example, on the question of whether the Government should support basic research at an increasing rate, the mathematician, MacLane, and the geologist, Verhoogen, take somewhat different views, as do the two economists Johnson and Kaysen. Nevertheless, a common viewpoint does permeate a surprising number of the essays. The purpose of this summary is, therefore, not to repeat in abbreviated form what is said so much better in the essays. Rather, it is to identify the common threads in the many different approaches to these problems, as well as to point up the sharpest areas of disagreement. The committee is encouraged that problems as difficult as those raised by the House committee can elicit fairly congruent analyses, and even similar answers, from men of widely different backgrounds.

The papers fall into three groups. Eight of them are concerned broadly with the questions as stated by the House committee. These papers, by Bode, Brooks, Johnson, Kaysen, Kistiakowsky, MacLane, Verhoogen, and Weinberg, try to lay down general principles and to examine specific tactical questions arising in connection with the support of science They tend to have a philosophic, political-scientific, or economic flavor. Three other papers, by Kantrowitz, Teller, and Willard, are primarily focused on the relation between education and research. The remaining papers, by Blinks, Horsfall, Pfaffmann, and Revelle, depict the state of certain particular fields of science—biology, medicine, the behavioral sciences, and the earth sciences. These papers give the flavor of the substance of science by showing the intellectual challenge, the material requirements, and the relevance to our society of some specific fields of science.

The choice of whether to write on the general questions or on a narrower topic was left to each writer. As a result, not all aspects of the general questions, and certainly not all the particular fields of science, were covered equally. It was decided to leave out of the summary most of the discussion of particular fields since the essays on specific fields cover so small a part of science. On the other hand, we have tried in

this summary to present a somewhat more balanced analysis of the broader questions of strategy and tactics of Government support of basic research than emerges from any of the individual papers. Some of the issues, like the relation between education and research, are touched upon in almost all the papers, whereas the matter of geographic distribution appears explicitly in only one. In the summary the imbalance in the discussions of these questions is to some extent redressed.

Both questions put by the House committee involve the issue of allocation of resources. The first question was interpreted by most of the panelists as raising the issue: How should we allocate resources between science and the other activities of our society? The second question asks: How should we allocate our resources within science? In our summary we consider each question in turn.

Part One: The Allocation of Resources between Science and Other Activities

I. *Basic Science "as a Whole" Is Not the Issue*

We first restate Question I: *What level of Federal support is needed to maintain for the United States a position of leadership through basic research in the advancement of science and technology and their economic, cultural, and military applications?*

The first question as stated makes certain implicit assumptions with which not all the authors agree. Verhoogen questions whether the U.S. "position of leadership" in applications of basic science is as firm as the question implies: "The United States has, without doubt, mastered the technology of many fields; but brilliant engineering achievements are not to be seen exclusively in the United States, and our technological supremacy does not extend to all fields." And the concern over our ability to convert basic research into application effectively is the main topic of Teller's and Kantrowitz's contributions and a major theme in Bode's essay. Nevertheless, the reservations concerning American leadership are much less pronounced than the affirmations of it. Thus Kistiakowsky speaks of the beneficial interaction between "chemical research and the welfare and the position of leadership of the American Nation"; and Brooks points out that the United States enjoys a highly favorable balance of trade both in payments for technical know-how and in exports of products based on sophisticated technology. Moreover, the authors, almost without exception, concede that in most of basic research per se, the United States today stands preeminent. As Teller says, "* * * the United States enjoys an unquestionable lead in pure science." MacLane states: "Mathematics in the United States has recently been strikingly successful * * *" and Kaysen adds: "Our own

contribution to the stock of basic knowledge * * * has been so great that we cannot simply act as if the total were given independently of our own actions." Though Johnson argues that scientific leadership in basic research itself may confer a kind of international leadership that is appreciated only by a small elite of scientific sophisticates, Bode articulates the views of several others when he replies that science and technology, as intellectual fields, are important components in the struggle of cultures in which our country is engaged.

This colloquy, in touching upon the connection between basic research and its applications, brings out one of the most pervasive and essential points in the whole analysis. The question, as put, implies that basic research "as a whole" is a proper focus either for budgetary decision or for political action. With this several essayists sharply disagree. As Weinberg says, to bring order to our thinking about public support of research, it is first necessary to separate basic research done to support a practical mission from research done to further science. Brooks and Kistiakowsky (as well as Kaysen and Verhoogen) also find that dealing with basic research "as a whole" is impractical. They emphasize, however, the unpredictability of practical uses of basic research and therefore do not stress as much as does Weinberg the distinction between mission-oriented and nonoriented research. To them the distinction based upon who does the research (university, Government laboratory, or industry) appears particularly relevant.

Nobody on the ad hoc panel challenges the proposition that the purposes of Government, as opposed to the techniques of Government, are nonscientific. Thus, the question to which question I naturally leads: Why should our society support basic science at all, and the corollary question: how much basic science should we support? must be answered in terms that generally lie outside science. Brooks identifies four goals of society to which basic science contributes and which justify its support by society. Basic science, per se, contributes to culture; it contributes to our social well-being, including national defense and public health; to our economic well-being; and it is an essential element of the education not only of scientists but also of the population as a whole. In deciding how much science the society needs, one must decide how the support of science bears on these other, politically defined, goals of the society.

With these goals, and the relevance of science to them, the essayists, except for Johnson who expresses serious doubts, are in good agreement. In particular, most of the essayists, especially Willard, stress the importance of basic scientific activity in maintaining our system of scientific education, although Teller and Kantrowitz, and Bode with less fervor, insist that, though basic science is necessary, it has distorted the university's perspective toward applied science. Several essayists conclude

that this is not the case at present, and that men trained in basic research subsequently play key roles in applied research and other practical activities (see especially Brooks). Kistiakowsky notes that "education and research in basic science form the best base from which young scientists can develop their skills in applied fields." This disagreement with Kantrowitz and Teller perhaps can be attributed to the much closer and older relations between industry and universities in chemistry than in physics. As Brooks notes, the situation in physics will probably tend in the future to become more like that in chemistry.

A major divergence could lie between the viewpoints that basic science is a sort of long-range investment or social overhead, supported primarily because it will eventually lead to applied benefits, and that basic science is a part of culture, as is music, or art, or literature. None of the panelists holds the one view to the exclusion of the other. The difficulty in tying basic science too strictly to applied missions is summarized by many of the panelists: Basic research is unpredictable. Thus no man was bright enough to know that Roentgen's experiments with cathode rays would lead to the discovery of X-rays, which in turn would lead to vastly important advances in medicine.

On the other hand, granting that basic research is part of culture, why should the society single out this branch of culture for particularly favored treatment? As Johnson says, "* * * insistence on the obligation of society to support the pursuit of scientific knowledge for its own sake differs little from the historically earlier insistence on the obligation of society to support the pursuit of religious truth, an obligation recompensed by a similarly unspecified and problematical payoff in the distant future." Johnson recognizes, however, as he states later in his paper, that "* * * if the public is convinced that a scientific culture is desirable, it is perfectly appropriate for the taxpayer's money to be used to support scientists and scientific research." And Verhoogen, supported by others, adds "* * * human beings * * * want to know," which is to say: Science as culture is in itself a valid goal of the society. Moreover, as Brooks puts it, science is a publicly verifiable enterprise, and therefore its claim to public support can easily be validated.

But the argument for public support of basic science because it is a distinctive element of our culture is conceded by most of the panelists to be less persuasive than is the argument based on useful application of basic science. As Brooks says, "the basic difficulty with the cultural motivation for Federal support of basic research is that it does not provide any basis for quantifying the amount of support required." On the other hand, basic research viewed as an overhead necessary for the accomplishment of politically defined goals of the society, such as better defense, or better transportation, or health and longevity, though still difficult to quantify, is at least related to goals of society whose importance has been subjected to prior political judgment.

Which brings us again to a central point on which there is general agreement: that basic research "as a whole" is a misleading notion. It does not help our scientific policy-makers to view the allocation problem as one of basic research as a whole versus other activities of Government. On this crucial point at least three of the panelists, Brooks, Kistiakowsky, and Weinberg, agree explicity. Thus Brooks says: "The basic thesis of this paper adds up to the conclusion that the concept of a total science budget, which is implied by the questions asked by the House Committee, is probably not a very meaningful or significant one. Only in the restricted area of academic basic research does the concept of a Government-wide 'science budget' make a certain amount of sense * * * . The rest of the 'science budget' ought to be considered in a different context, in which the value of research and development is judged in competition with other alternative means of achieving the same objectives." Kistiakowsky essentially agrees with this view, although he divides basic research somewhat differently. Weinberg puts it thus: "The expense of science as a means to achieve a nonscientific end should logically be assessed against the budget for achievement of that end, not against some mysterious budget labeled 'Science as a Whole' * * *. The remaining basic sciences * * * would then be properly included in a budget which I call the 'Intrinsic Basic Science Budget.' This activity of our society * * * should properly be balanced against other activities of the society—for example, education and foreign aid * * * the choice between intrinsic basic science as a whole and other, nonscientific, activities is the primary relevant political decision."

II. *The Government and the Market Place as Supporters of Research*

From the conclusion that basic research, either as culture or as a long-range investment for the achievement of society's other goals, is desirable, to the conclusion that Government must therefore provide large-scale support for basic research is a step that requires argument. Johnson's paper makes the necessity of such argument explicit: He points out that there are mechanisms in our society and economy that would provide financial support for basic research subdivisions, so that the question is not one of "all or nothing" but whether privately financed research would be adequate. As Johnson puts it, "In order to establish a case for Government support, it must be shown that basic research yields a social return over its cost that exceeds the return on alternative types of investment of resources. Alternatively, it must be shown that the amount of basic research that would be carried on in the absence of Government support would be less than what would be economically optimal." He agrees with Kaysen, however, that the market may not provide enough or the right balance of support. Therefore the society cannot rely upon the market completely and must supplement it, especially since much of

science is a byproduct of higher education, which is certainly of immediate public concern. Hence the Federal funds become involved but the question remains whether the present commitment is too little or too much. He makes a case for more reliance on support of basic research by sources other than the Federal Government. Johnson also argues that since basic research done by one country is available to all, there are limits to how far the United States can profitably go in attempting to maintain leadership across the board in basic research.

All the other general papers endorse the desirability of large-scale Federal support of basic research, and explicitly or implicitly reject the view that the private marketplace should be utilized more and Government sources less for seeking support for basic research. Thus Bode responds to Johnson's suggestion that foreign basic research can be transplanted by tracing the history of technology. In the early days, technology flourished with relatively little fertilization from basic science. Leadership in science was usually uncorrelated with leadership in technology; but as technology, especially military technology, has become more sophisticated, its reliance on basic science has grown. Today, the connection between basic science and technology is so close that to Bode it is unthinkable to maintain leadership in technology without maintaining an indigenous supporting basic science. It takes trained people of highest order to apply modern science to our sophisticated technology. Such people, who must be trained in our own, indigenous, educational and research system, will be available only if we have vigorous basic research of our own.

Kaysen responds to "But why the government?" by pointing out that, just because its contribution to our nonscientific goals is so unpredictable, basic research is a proper concern of the one element of our society responsible for the general welfare—the Federal Government. The marketplace always underinvests in social capital or social overhead. The economic and social benefits of basic research cannot be wholly recaptured by the private institution that finances it, but only by society as a whole. Hence the Government cannot rely either on the marketplace or on institutions with regional or specialized interests to support the volume of basic research that would benefit the economy as a whole. Moreover, some of the fruits of basic research, for example, those related to "military capability, fall directly within the sphere of Federal responsibility, and only the Federal Government can and will pay for them. This applies both to military requirements for applied research and development, and to the insurance value of the scientific reserve corps." This general view is shared by Brooks.

And, finally, Weinberg argues that much of the basic research supported by the Government is justified by its direct relevance to specific, politically defined goals of Government. For example, once the political decision is made by the Government, say, to desalt the sea economically,

then the Government must do whatever is necessary in the judgment of those responsible for developing techniques of desalination to achieve it. If, for getting on with the job of desalting the sea, basic research on sea water seems more important than building another pilot plant, then the Government must see to it that basic research on sea water is done. Insofar as basic research is done to accomplish specific applied missions of the Government, such basic research is obviously the job of the Government. This kind of basic research constitutes a substantial part of the basic research conducted by the Government. It is only the other part, which is not so obviously relevant, about which there can be serious argument as to its relevance to the goals of Government.

III. *Mechanisms for Allocating Support*

We consider now the mechanisms for determining how much basic research Government ought to support. Since, as the previous discussion stresses, basic research "as a whole" is not a very useful concept, different mechanisms and different justifications are appropriate for the differently motivated segments of basic research. The entire mechanism for allocating support (and by implication, the total to be supported) turns out to be a collection of separate mechanisms (and separate subtotals).

The precise partitioning of all basic research into components is, of course, largely arbitrary. Basic research can be classified in terms of its motivation—as culture, as an adjunct of education, as a means to accomplish nonscientific goals of the society; of its sources of support, whether mission-oriented agency or science-oriented agency; of its performers, whether university, Government laboratory, or private industry; or of its character—whether "little science" or "big science." Any one of these classifications, if applied consistently, could cover all basic science, but none is wholly satisfactory; hence, the different classification schemes crisscross each other and are somewhat incongruent. For some purposes, one classification scheme is more convenient than another. In this discussion we shall use elements of all the schemes proposed in individual essays. Though this may cloud some of the underlying philosophic issues, it accords more nearly to the actual situation than does a strictly logical classification, and as Brooks puts it, in some cases leads more naturally to a basis for allocating resources to science.

For the purpose of answering the first question, i.e., how much should be allocated to basic research as a whole rather than to other activities of the society, the classification suggested by Brooks and Weinberg is germane: the larger part of basic research is tied to specific, nonscientific missions of agencies; a much smaller part is not directly relevant to missions. Let us consider first the larger part—the basic research done by mission-oriented agencies to accomplish their politically defined, nonscientific, missions.

As we have already said, such basic research is supported by the agency because the agency believes that basic research is a better place to allocate its resources than is some alternative, like procurement, transportation, or communications. This basic research is an overhead expense, since it is performed primarily not for the sake of the basic research but rather for the sake of the agency's mission. But how does one decide what fraction of the agency's resources should be allocated for basic research to accomplish even the most specific mission? Johnson argues that our understanding of cost/effectiveness of basic research is too insecure to allow even the mission-oriented agencies to decide what a reasonable allocation to mission-oriented basic research should be. Or, as Kaysen puts it, "It is in the very nature of an overhead that a nice calculation of the 'right' amount to expend on it is difficult." Difficult, but not impossible, suggest Brooks and Weinberg. Every business, in every part of its operation, makes the same sort of overhead calculation as goes into an agency's estimate of how much basic research it needs to accomplish its mission. Weinberg suggests that the amount of such support should be geared to an estimate of just how much the agency's applied mission derives from past basic research—perhaps 10 percent for agencies whose missions depend on scientific knowledge heavily, perhaps less for agencies that need science less. Brooks suggests that "10 to 15 percent of the applied effort might be a good rule of thumb for the basic research effort." These judgments of the percentage going to basic research, would be decentralized in the sense that they would be left primarily to the agency, but they would be reviewed, as is any overhead expense of an organization, by other interested parties in Government, like Congress, the Bureau of the Budget, and the Office of Science and Technology.

The basic research of an agency is thus related to the applied or developmental effort of the agency: The main problem, as indicated above, is to determine what fraction of the overall agency budget should go into basic research. But evidently, as pointed out by many of the panelists, and especially Brooks and Verhoogen, this method of supporting basic research as an overhead on applied missions, logical though it may be, also causes trouble. Basic research closely tied to an agency's nonscientific goals suffers from the vagaries of agency budgeting and agency management. If it is to be effective, basic research cannot tolerate such fluctuations, whether they are imposed by fluctuating budgets or by fluctuating opinions within an agency as to the relevance of particular basic research to the agency's mission. Mechanisms are needed both to smooth out the fluctuations in mission-supported basic research and to enlighten agency managements about basic research.

Here the National Science Foundation is viewed as playing a decisive role. The National Science Foundation is the sole agency of Government whose purpose is support of science across the board and without

regard for immediate practical gains. If there is good basic science ready to be done but which does not as yet command support from some mission-oriented agency, then the National Science Foundation must be equipped to step in, if it chooses, to pick up the tab. Thus the National Science Foundation is viewed by Weinberg as being responsible for what he calls "Intrinsic Basic Science," the motives for which are relatively remote from politically defined missions. Since this is a social overhead whose connection with specific applied objectives of the society is distant and undefined, it would seem, as Kaysen stresses, that allocation of resources to this activity would be even more difficult than the allocation to mission-related basic research.

And, indeed, Weinberg insists that just this decision—how much should go for "Intrinsic Basic Science"—is the primary political decision that faces Congress. Moreover, he visualizes this decision as coalescing more and more with the decision as to the budget for the National Science Foundation if, as seems likely, more and more of this kind of science gravitates toward the National Science Foundation.

In the analyses of Brooks and Kistiakowsky, the National Science Foundation is also seen assuming the role of a "balance wheel" to soften the impact of variable research policies of mission-oriented agencies on "academic basic research" or "little science." Looking at the problem more from the point of view of the "performers," however, they realize that most of this type of research, although not immediately related to the practical missions, is nonetheless supported now by those mission-oriented agencies that choose to interpret their research tasks broadly.

As an illustration we may cite the finding, based on a recent survey by the chemistry panel of the Committee on Science and Public Policy, that the National Science Foundation contributes only 23 percent of Federal funds to support basic research in university chemistry departments. And yet this is typical "little science." In fact, the same individual "performers," that is, chief investigators, receive funds from the National Science Foundation and from mission-oriented agencies for research projects that are not different in kind and frequently overlap closely. This is related to the unpredictability of basic research (see Kistiakowsky): What to one may seem to be "science for science's sake," to another may have germs of exciting but as yet uncertain practical applications.

If this view is appropriate, the formal separation of "Academic Basic Research" into "intrinsic" and "not so intrinsic" would be very difficult from the points of view (far from uniform) of both the Federal agencies and the performers. Hence the recommendations of Brooks and Kistiakowsky that other agencies continue supporting academic basic research without a reappraisal of what is relevant to their missions (implied in Weinberg's arguments), but that the National Science Founda-

tion grow into the role of the "balance wheel," assuring steady progress of such research.

Whichever breakdown turns out to be most useful, are there criteria for judging how much should go for this kind of science; i.e., how much, eventually, should go to the National Science Foundation or to any other agencies carrying responsibility for "Academic Basic Research"? The panelists generally take for granted that the present situation, which has led to our position of leadership, should be used as a baseline. Several of the panelists argue that the amount should increase on two general grounds: First, as Kistiakowsky and Bode suggest, our society is becoming increasingly scientific. As science helps to improve our material or personal well-being, our appetite for more improvements grows. Since the advanced technologies on which these improvements depend make ever greater demands on basic science, this trend will be reflected in an increasingly scientific culture and therefore an increasing effort in basic science. Moreover, as the wealth of our industrialized society increases, we can afford to put a larger share of our wealth into science that furthers the more sophisticated needs of the society. Second, basic science is inextricably related to the education of scientists, who are so essential to the modern industrial society. Our society is committed to the idea of providing its citizens with adequate education. Insofar as academic scientific research is connected with scientific education, the growth of our student body implies a growth of science. This is emphasized by Kistiakowsky, Willard, and Verhoogen. As Brooks says, one great advantage of tying support of science to education is that educationally justified science is the easiest to quantify: One may look mainly at the projections of population and guess how many more science students will be entering the universities some years hence, and make adequate preparations for this.

But a strict separation into mission-oriented basic research and intrinsic basic science hardly provides unequivocal clues as to how much science, particularly of the latter sort, we need. This separation is useful primarily because it suggests where in the Government the problem should be looked at. Mission-oriented basic research is the business of most agencies, whereas intrinsic basic research is the business of the National Science Foundation or of other agencies which, as Weinberg puts it, have become, in part, "little National Science Foundations." To find clues as to how much basic science we ought to support, as opposed to who should support it, we therefore return to the classification schemes used by Kistiakowsky, Brooks, and Kaysen, which divide science into "little science" and "big science." The way would be clear indeed if all "little science" and "big science" were congruent with all "intrinsic basic science." This is not the case. The professor and his small group of students, the typical performers of "little science," are often supported by a mission-oriented

agency because it judges the professor's basic research to be fairly relevant to the needs of the agency. The totality of "academic science," or "little science," is very much larger than the National Science Foundation research budget.

"Little science" as defined in several essays is largely academic science. It is highly individualistic, and the performance varies greatly among the fewer than 100,000 people who do it. As evidenced by the agency records of rejected applications for funds (see Willard), far from all these people receive Federal support for research. Kistiakowsky's estimate is that in 1963 the total cost to the Government of "little science," including facilities and fellowships, was approximately $600 million. The opinions of panelists as to the desirable level of support vary somewhat. Verhoogen believes that every qualified scientist should be provided with adequate support, provided his activities are within the fiscal range of "little science" (e.g., $20,000 or less per annum) and provided his research is subjected always to the scrutiny of his peers. Brooks and Kistiakowsky (and less explicitly Kaysen) take the present situation as a satisfactory starting point, and the first two argue that a 15 percent annual increase will meet national needs.

Brooks's argument, which is the most explicit, is based on a forecast of the population of graduate students and faculty, and the 15 percent annual increase is suggested as minimal rather than as a necessarily adequate level to take care of expanding educational needs. Finally, MacLane, directing his attention to theoretical sciences, holds that every potentially original scientist should be provided with adequate support, while by implication he holds that the growth of the research budget should depend in some fashion on the growth in the number of outstanding scientists. Verhoogen's point of view calls for larger growth because: "in other fields (other than mathematics) we still very much need to assemble the verifiable facts on which new ideas may grow."

We now turn to "big science," some of which is "academic science" and some clearly mission-oriented (e.g., the scientific satellites). This science centers around research equipment, some of which is so costly that it in itself represents a significant element in the total national budget. As Kistiakowsky puts it: " 'Big science' is fiscally open-ended because the commitment of *scientific personnel per project* is rising comparatively slowly and the costs are concentrated in the engineering effort. * * *" Hence, the principle of supporting every good man in "little science" is not very useful for "big science." It is obviously impossible to provide every high-energy physicist with his own accelerator. As stressed by Kaysen, Kistiakowsky, and Brooks, the decentralized methods of allocation that characterize the panel system under which "little science" is governed must for "big science" be replaced by much more centralized planning and deliberation. *Each* "big science" project

obviously demands special judgment and action and, since the size of each such expenditure is so great, the decisions will have to be made at the highest levels of Government with the strongest interplay between the political and scientific communities; in the words of Brooks, they are strategic decisions. Thus, although a total budget for "little science" can be arrived at a priori by adopting some such principle as: Support every *good* man (especially if he contributes to the educational process), or, use the present generally satisfactory situation as a basis for reasonable expansion, no a priori judgment can be made for "big science." Each instance of "big science" must be examined by itself, and must find its place not only as part of the science budget but also as part of the entire national budget.

IV. *The Self-Equilibration of Scientific Growth*

Support of "little science" at a level that assures every qualified scientist of adequate support may run the danger pinpointed by Johnson, who says, "Ultimately it (such a policy) relies on the self-equilibrating processes of the intellectual market in ideas and the commercial market in scientifically trained labor to prevent serious misallocations * * * the approach depends on a particular assumption * * *: that there is a limited and fairly readily identifiable group in the population that is capable of acceptable scientific performance, and a sharp difference in ability between this group and the rest. ... This assumption does not make economic sense in any long-run perspective: One would expect the supply of potential scientists, like the supply of any other kind of skilled labor, to vary in response to the income and career opportunities offered."

Most of the other panelists, insofar as they touch on this question, don't agree with Johnson. Their view is that the number of people interested and qualified in science is limited, and, because science is so demanding, will always remain limited. Moreover, the "self-equilibrating process of the intellectual market" is generally thought to work very well, especially in Kistiakowsky's view. The panel system, the internal criticism that characterizes the scientific community, the institutional standards established by the universites, at which so much of "little science" is performed—all of these keep basic science honest, keep it demanding, and will always keep it relatively small.

One of the panelists, MacLane, devotes his paper primarily to the question of standards in science; he is concerned that the growth of science budgets should not be so explosive as to erode these standards. He holds that the fruitfulness of science depends vitally upon the presence of relatively few top-quality scientists. Hence he argues that a first allocation of resources should be to support top-quality scientists, whatever their choice of subject or field. This might yield a system of allocations with multiple criteria: some basic research supported accord-

ing to its relevance to the missions of various agencies; other basic research supported because scientists of proven excellence judge it worthy of pursuit.

Brooks, in a sense, imposes a similarly stringent set of qualifications on those eligible for support simply because they are really good. He estimates the number of truly outstanding "little scientists" as being only around 5 percent of all the active basic research scientists, and that their support is justified purely on cultural grounds. Brooks urges support for the rest of "little science," but not solely on cultural grounds or on the grounds of supporting good people; rather, it is on the basis that what the remaining "little scientists" do is necessary for our expanding educational system, and that it is germane to applied mission of Government.

Kaysen goes further along this line and recommends, in much the same spirit as Weinberg, that the support of basic science be defined as an overhead on total expenditures for applied research and development, with the proportion of the total set initially at its historic level of 9 percent.

V. *We Must Improve the Connection between Basic and Applied Science*

Since what emerges from the essays is a preponderant opinion that the primary justification for Government support of basic research lies, aside from education, in the expectation of payoff, we must examine more carefully the efficiency with which our Nation has been able to convert successes in basic research to practical advantage. This is the substance of the discussion by the physicists, Teller and Kantrowitz, and looms large in Bode's thinking. Teller puts the problem succinctly: "Most of our Federal expenditure is used to support applied science and the engineering developments based upon applied science. At the same time, most of our educational effort on the relevant graduate level goes into the support of pure science. As a result, the most massive expenditures of our Government suffer from inadequate technical leadership." Teller and Kantrowitz argue that the strong encouragement of basic research in the universities has created an environment that is uncongenial to applied research—so uncongenial that even universities that were organized to pursue applied science and engineering now turn out many graduates who have no taste for anything but pure science.

But many of the panelists believe the universities do play a notable role in maintaining our strength in applied research. For, as Brooks suggests, there is a steady flow of people trained in university-type research who go into applied science, "which has been one of the characteristic features of American science that has contributed to its vitality" (see also Kistiakowsky). This indeed is one of the important ways in which the results

of basic science are converted into applied payoffs. And neither Teller nor Kantrowitz nor Bode wishes to disturb our position of leadership in basic research, established largely because the government has supported basic research at the universities so steadily. Rather, the former two suggest a new educational pattern for applied science in which the citadels of basic research, the universities, and of applied research, the industrial and Government laboratories, form joint entities devoted to graduate education in the applied sciences. The degree would be conferred and the academic standards would be maintained by the universities; the graduate thesis and much of the instruction would be the responsibility of the cooperating laboratory. Many such arrangements are springing up in the United States. However, since in many cases the laboratory is an agent of the Government, these arrangements often are hampered because of Government regulations concerning the propriety of using Government facilities for educational purposes. Explicit sanctioning of such arrangements by the Government is urged by both Teller and Kantrowitz.

Part Two: Allocation of Resources within Science

The second question, What judgment can be reached on the balance of support now being given by the Federal Government to various fields of scientific endeavor, and on adjustments that should be considered, either within existing levels of overall support or under conditions of increased or decreased overall support, raises the question of allocations within science. It thereby involves possibly fewer elements of public, as opposed to scientific, policy than does the first question. In dealing with this question, the panelists tended to broaden its scope to include not merely the allocation among fields of science but also allocations among institutions engaged in science.

We have already examined various subdivisions of science—into mission-oriented and non-mission-oriented; into "big" and "little"; into "basic" and "applied"; into science at universities and science outside of universities—and we have discussed how the panelists have used various subdivisions, as they found appropriate, to discuss the total budget for all basic research. For making allocations within science, two subdivisions seem particularly appropriate: By field of science, and by institution; allocations within the first subdivision may be called "scientific choice," within the second "institutional choice." These choices are related to considerations of the sources of support and the performers.

I. *The Criteria for Scientific Choices*

The problem of "scientific choice," that is, deciding how to allocate funds to different fields of science within a total science budget, has been debated publicly since 1958. As a means of clarifying the issues

in this debate, several committees of the Academy and some groups directly sponsored by Federal agencies have prepared reports dealing wih the opportunities and requirements of specialized fields of modern science. These include reports on oceanography, atmospheric sciences, and high-energy physics. Several major efforts to cover other areas of science have been undertaken since 1962 by groups of experts in cooperation with the Committee on Science and Public Policy and sponsored mainly by the National Science Foundation. We refer the reader to one such effort—a report, *Ground-Based Astronomy: A Ten-Year Program* (National Academy of Sciences, 1964), as an example of what can be achieved by a highly competent group (working on a part-time basis, of course) in approximately 18 months. Other such reports, on the academic uses of computers, on physics, chemistry, and the plant sciences, are in various stages of completion and are expected to be available before the end of 1965.

These reports will still leave many major scientific areas unexamined, and thus will not provide sufficient basis for the formulation of a balanced answer to the second question of the House committee. As an expedient to bridge the gap, four members of the ad hoc panel prepared papers on scientific areas in which they have special competence. Of these four essays, those by Blinks and Horsfall deal with essentially the same scientific area—life and biomedical sciences—but from quite different viewpoints. The essay by Blinks emphasizes the unity and interdependence of life sciences and brings out the great gains in our knowledge of life processes that can accrue from biological research. Horsfall's article describes the impressive breadth of scientific fields that now have relevance to health problems, and establishes ties between basic and applied research in these fields. Revelle's essay traces the close connection between research in earth sciences and future progress and conservation in many areas of the civilian economy. Finally, Pfaffmann's essay stresses the point that many areas of behavioral sciences have advanced to a stage where objective scientific research is feasible and is rewarding from the point of view of social benefits; also that such research, no less than research in natural sciences, requires major investment of financial resources.

Since these essays do not pretend to be full committee reports, and since they do not begin to cover all fields of science, the panelists felt they did not have information on which to base recommendations for allocation of resources among fields. Instead, most of the panelists who spoke of this problem tried to lay down principles for making the judgments on allocation among fields that the House committee asked for. The underlying strategy suggested by many of the panelists, notably Kistiakowsky, Kaysen, and Brooks, was to separate "big science" from "little science," and to use different criteria of choice for them. Briefly, these panelists

recommended that allocations within "little science," or, almost synonymously, "academic basic science," should be made by the free play of the scientific marketplace of ideas. The prior assumption, already discussed in Part 1, is that, starting with the present situation, which has given us leadership, every really good man, especially if he helps the educational process, should be supported. No one knows as well as he does what is a fruitful or useful direction for his basic research; his work is continuously scrutinized and monitored by his scientific colleagues; and hence he should be allowed to decide what facet of science to pursue. The total allocation within "little science," broadly, is the sum of innumerable individual judgments by individual scientists. Such a self-equilibrating system of allocation is almost the only one that can ensure continued long-term viability for our preciously individualistic "little science."

Kaysen sharpens this strategy: He also accepts the play of the scientific marketplace within fields of basic science—e.g., in physics or in chemistry—but he pleads for a more deliberate comparison of fields by a mechanism that takes into account the total number of active researchers and the number of new Ph. D.'s produced in a field to guide allocations to that field.

The criteria for choice in "big science" must be very different, partly because of the open-endedness of "big science," already mentioned, and partly because any single decision may affect a large sector of science. Thus, whether a 200-Gev accelerator is built or is not built is a matter that will profoundly affect the long-range future of American high-energy physics. Three of the panelists consider in some detail the problem of allocation of resources within "big science." Kaysen recommends that the proposed projects be scrutinized as to their competitive merits by a group composed of the representatives of the funding agencies and of "performers" in various sciences. The evaluation process must involve the fusion of the elements of technical "ripeness" or urgency of particular projects, and political considerations. Kaysen suggests further an ingenious "tax" on "little science" to finance a part of the costs of "big science." "This cost-sharing arrangement would appear as another useful administrative control device, directed toward making those representatives of any (scientific) field not themselves too directly concerned with using large facilities sensitive to their costs in terms of their own interests." Brooks classifies the entire research funds into three categories: (1) the capital costs of "big science" facilities; (2) the operating costs of such facilities needed to make them available to the scientific community; (3) the strictly scientific costs of research involving the facilities. This last item he treats as part of "little science" and segregates it from (1) and (2). Item (2) has occasionally been insufficiently allowed for in the past, with serious effects for progress of science, and

Brooks urges its careful consideration when making decisions regarding (1). "The decisions regarding allocations under (1) are the only decisions regarding allocations between fields of science that should be made at the highest levels of Government * * *. They are the basic investment decisions of the Federal Government * * * that determine the scientific priorities for many years ahead * * * in which the price of error is highest." Brooks goes on to say that he agrees with Kistiakowsky's criteria for ordering the priorities of "big science" projects. Kistiakowsky starts from Weinberg's criteria (published in *Minerva,* Winter 1963) but revises them for "big science." The following factors emerge as most important in making the decisions that Brooks calls strategic: (a) commitment of qualified scientists to a project; (b) the relevance of the project to adjacent and significant branches of science; (c) the potential impact of the project on practical applications; (d) its impact on national prestige and international influence; (e) the broad cultural impact of the proposed undertaking.

All the panelists who deal explicitly with the subject emphasize that decisions regarding allocations within "big science" must be centralized at a high level in Government, and that decisions regarding allocations within "little science" must be decentralized.

II. *The Criteria for Institutional Choices*

But, Kistiakowsky insists, even in "little science" the scientific choices cannot really be separated from institutional choices. Where the "little science" is done, whether in Government laboratories, or universities, or industrial laboratories, must affect, if nothing else, the degree of permissiveness that the agency can allow in the support of the research.

Kistiakowsky and several other panelists argue that general, non-mission-oriented, basic research in the universities, above all, needs strengthening even at the expense of such basic research in other institutions. Perhaps Willard states the case most explicity: First, that because of our growing population, education in general and education in science in particular must increase. The need for more education is inexorably growing, and must take precedence over other needs. Second, that the universities have proved in the past that they provide the climate (the "ecology" as Brooks puts it) most conducive to distinguished achievement in basic research. Thus, the Government gets its best money's worth for a dollar spent on undirected basic research at the university and, if institutional choices are to be made in disbursement of funds for such basic research, the university should have first claim.

The nonuniversity members of the panel do not choose to respond precisely to this challenge. Kistiakowsky strongly supports relevant basic research in the Government and industrial laboratories—all created for practical purposes—while rejecting the substitution of general research

for a valid applied mission. Verhoogen, who makes a strong case for basic research in the universities, argues for continued vigorous basic research in the Federal laboratories on three grounds: First, because "their research (e.g., meteorology and weather prediction) is commonly of a kind and scope that cannot be carried out in universities. That is, it is "big science," a point on which no panelist disagrees. Second, competition in science is good, and Government agencies may set standards of excellence in research that private institutions should equal or surpass. Finally, it is difficult * * * to ensure that science will move forward with the necessary vigor on all fronts * * *. By a judicious choice of its own research program, the Federal Government can to some extent correct the imbalance."

The seeming divergence between Kistiakowsky's view and Verhoogen's is not very sharp. Both agree that mission-related basic research is necessary in the Government and industrial laboratory; the point at issue is really where one draws the line between mission-related basic research and non-mission-related basic research. Kistiakowsky would possibly draw the line more sharply than some of the other panelists, and would tend to keep out of, or at least not expand in, the mission-oriented laboratories, some parts of basic research that are now pursued in such institutions. Brooks, in much the same vein, suggests that the amount and kind of basic research in Federal laboratories should be primarily the decision of the laboratory management, subject to the constraint that the total budget of the laboratory be governed by the importance of its practical mission and its long-term success in accomplishing it.

III. *Geographic Distribution of Research*

The matter of institutional choice inevitably leads to consideration of geographic distribution of research support by the Government. If one supports only excellence, and if excellence exists, as MacLane implies, at only a limited number of established centers ("One cannot have more centers than the population of scientists allows."), how does the country redress imbalances in its economic and cultural growth that are connected with geographic distribution of scientific activity? This is a question asked explicitly only by Johnson; yet it is obliquely implied in several other papers. Johnson urges a deliberate policy of locating scientific research in the backward areas of the country to encourage their industrial development: "So long as public funds are allocated to the support of basic research, the geographic allocation of the funds should take account of the social effects of their expenditure."

That this issue is not discussed in the other general essays probably results from the fact that the Committee on Science and Public Policy had already taken a stand on the matter. In its 1964 report, *Federal Support of Basic Research in Institutions of Higher Learning,* the Com-

mittee on Science and Public Policy recommended special Federal action to assist selected institutions in attaining higher levels of excellence, emphasizing at the same time the great difficulty of making the right choices.

To some extent, the project system of granting Federal support to science may have slowed down a process of dispersion of scientific resources, which might not have been slowed down under different systems of support. Brooks recommends a gradual transition to a situation in which about 25 percent of the costs of "little science" goes to supporting people, 25 percent is institutional support, and about 50 percent is project support.

The problem of geographic distributions of Federal funds for research is taking on increasing importance in the eyes of Congress. Whether it will tend to go away of its own accord, or how much the process of diffusion of scientific excellence can be accelerated without sacrificing the excellence itself, are questions on which additional thought is needed beyond what was given in the report, *Federal Support of Basic Research in Institutions of Higher Learning.*

IV. *The Age of Biology and the Crisis in Physical Sciences*

Though the panelists could not fully address themselves to the question of scientific choice (inasmuch as the necessary data were not available), nevertheless two themes in this connection are discernible. One impression created by several panelists is that the next decade ought to be the age of biological science. As Weinberg puts it, "The National Institutes of Health seems * * * to be the Government agency, the achievement of whose mission is most directly and obviously dependent on a great push in our understanding of an underlying basic science (biology), and whose mission will continue to enjoy greatly expanding public support." Or as Blinks says, "Many physical scientists feel that support should be even greater for biology (than the 15 percent per annum suggested for 'little science' as a whole) as it enters an era of unprecedented fruitfulness."

On the other hand, Weinberg sees the physical sciences confronted with a deep financial crisis: "* * * the necessity of expanding basic physical science research in order to further the missions of * * * the Atomic Energy Commission, the Department of Defense, and the National Aeronautics and Space Administration is not * * * obvious * * *." Yet, since orderly expansion of these sciences is a necessary element in the general growth of the sciences—in education if nowhere else—"* * * basic research in the physical sciences is faced with a crisis. Most of its support has come from the mission-oriented agencies, but these agencies (faced with stationary budgets) will probably not expand their support of basic research as fast as our capacity to do basic research (in the physical sciences) expands."

Part Three: Government Decisions and Actions

What specific actions do the panelists call for from the Government agencies and from Congress? Two kinds of actions seem to be called for by various panelists: In one group are additional staff studies and statistical analyses; in the other are broad and, in some instances, crucial decisions that affect our whole governmental organization for science. These latter actions in a sense constitute a sort of operational answer to the questions put by the House committee.

I. *Statistics on Research*

Statistics on research and development in the Federal Government are complex, and sometimes misleading, not because the dedicated statisticians and analysts who amass these figures are incompetent, but rather because the situation is inherently so complicated. As Brooks says, "A recent report of the Organization for Economic Cooperation and Development has remarked that most countries have better statistics on poultry production than they do on the activities of their scientists and engineers. To some extent this is inevitable since the product of scientific activity is an elusive entity which defies measurement." Brooks then goes on to analyze some of the difficulties: It is very hard to decide what is basic, what is applied; what is academic, what is nonacademic; what is research, what is education; or even what is Federal, what is non-Federal. There is probably no easy way to improve our statistical picture of research in the Federal Government: essays such as Brook's point out the complexities and may help Government administrators bring their data together in more useful ways.

One aspect of research statistics is particularly troublesome: this has to do with estimating the cost/effectiveness ratios of research. Here it is not so much a matter of statistics. Rather, as Johnson implies, there are exceedingly difficult questions on which professional economists are still groping for ways to make progress. He suggests that additional research be done on this group of questions. Pfaffmann echoes this in urging wider support of behavioral sciences research generally on the economic and social implications of science and technology.

A few specific statistical studies are suggested by some of the essayists. For example, Weinberg suggests that the Government try to establish how the support of basic research in each field of science is now distributed among the agencies of Government. Since some basic science is mission-oriented and some is not, it would be useful to know how the agencies differ in their assessment of relevance of basic research to their missions. Kistiakowsky notes how uneven this assessment now is.

II. *The Role of the National Science Foundation: Conclusions*

Two really major conclusions emerge from these papers. The first is that Government should recognize that, on the whole, science in the United States today enjoys preeminence, and that what is done in the future should be based on expanding and improving the present situation. Though some illogicalities may exist, of course, in the conduct of so large an activity as Government-supported science, it has so far been effective and there is no reason to change it drastically. In a sense, this constitutes the simplest answer to the first question. The more detailed suggestions by various panelists: To look at academic research separately from other research, or to provide support as broadly as possible for "little science," or to treat "big science" differently from "little science," are inherently complex and are made against a background of belief that the Government's scientific policies in the past have been generous and responsible, and that U.S. science has done very well indeed.

The second essential point that runs through at least half the papers is the belief, stated either explicitly or implicitly, that the role of the National Science Foundation during the next decade should become much greater than it has been in the past, especially in the physical sciences. The crisis in the physical sciences has already been alluded to. As the handmaiden mostly of mission-oriented agencies such as the Atomic Energy Commission, the Department of Defense, and the National Aeronautics and Space Administration, whose missions are not likely to expand in the immediate future, these sciences are caught in a squeeze. Yet, as many of the panelists have argued, the physical sciences should expand, though perhaps not as rapidly as the biological sciences.

The reasons for such expansion are: (1) That biological and environmental sciences, to which Government is already heavily committed, will increasingly depend on advances in and people from the basic physical sciences; (2) that although military and space research and development expenditures appear to be declining, the Nation must continue to build up its stock of knowledge and people in the physical sciences, on which future advances in military and space technology will rest if a later emergency requires renewed emphasis on these fields; (3) that the physical sciences rather than the biological sciences have been the major source of past improvements in civilian technology, and support of them is, therefore, important for the further growth of productivity in the U.S. economy.

Two courses for providing increased support to the physical sciences are open, and probably both should be followed. The first, recommended by several panelists, is that the mission-oriented agencies, at times such as this when budgets are rather stationary, should devote a larger fraction of their budgets to basic research. This implies that they incline toward a broader interpretation of what kinds of basic research they

deem relevant to their missions than is sometimes the case now; or even that Congress extend the mission of the agency to include the pursuit of certain branches of basic science, if this is necessary.

The second course, which by no means excludes the first, is to make the National Science Foundation a much larger agency than it now is—so large that it can eventually become the "balance wheel," or even the main "umbrella," for the support of basic research—especially in the physical sciences—that is too remote to merit support from the mission-oriented agencies. Such a specific policy with respect to the future growth of the National Science Foundation involves a major political decision by Congress and by the executive branch, as formidable and far-reaching as its decision has been with respect to expansion of the National Institutes of Health.

The Crisis Facing American Science

A preliminary report on the effects of decreased federal support of scientific research and education

THE NEW YORK ACADEMY OF SCIENCES, AD HOC COMMITTEE FOR EVALUATION OF FEDERAL SUPPORT OF SCIENCE

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Foreword

To help control inflationary pressures, Congress recently enacted The Revenue and Expenditures Control Act of 1968, which, among other things, required a cutback of $6 billion in government spending. The effect of this retrenchment on scientific research and education has, in the opinion of many active and responsible scientists, been to seriously undermine the potential benefits of science to the economic and human health of the nation and, in turn, the world.

Members of The New York Academy of Sciences, who represent a large segment of the scientific community, have been increasingly concerned with the problems created by the relative decreases in the support of scientific research and education during the past several years. With the announcement on May 30,

*Nobel Laureates.

1968, of the mandatory $6 billion budget cut, the Academy felt compelled to take action.

An emergency town meeting of scientific representatives of government, educational institutions, learned societies, private research institutes, and industry was called on June 21, 1968.

Its conclusions:

> Failure to provide adequate support for scientific activities has already resulted in serious setbacks to research and education, and could result in long-range dangers to the welfare of the nation and the world.
>
> The expression of the scientific community's point of view has been late in coming. Those in positions of political decision who decide on allocation of funds cannot be expected to have the same awareness as scientists. Thus scientists can no longer afford to overlook the realities of politics and the attitudes of the public.
>
> Despite budget stringencies, immediate first aid measures must be taken to identify instances where blanket cuts may cause unintended, irreversible damage to important scientific programs.

Following a meeting on July 30, 1968, with President Johnson and his science advisor, Dr. Donald F. Hornig, Academy representatives proceeded with a survey of academic institutions Academy members designed to elicit evidence of present and potential damage to science and the nation of past, current and impending reductions in federal support.

This report, based on the survey, documents and analyzes those dangers and proposes a program to maintain the country's world leadership in science—a leadership that has given to the American scientific community world-wide responsibility to continue its search for solutions to mankind's most fundamental and pressing problems.

Summary of Findings and Recommendations

These findings summarize a broad spectrum of opinions and facts presented by the 84 academic institutions and 193 individual scientists responding to the Academy's survey. While there were inevitably differences of opinion in such a diverse sample of organizations and individuals, the comments were in remarkably close agreement.

Not surprisingly, most respondents speak of the adverse effects of the reductions in federal support. A small minority find some offsetting gains, in the form of better discipline and closer planning of current and future spending. In general, however, these enforced virtues are regarded as overwhelmingly offset by the loss of opportunity and continuity in scientific research that are the bitter fruits of the budget reduction. The nature of these losses is set forth in greater detail below, and documented, in the words of the scientists and university officials involved, in the appendices of this report.

The recommendations of the Committee are neither elaborate nor detailed. They constitute, in the Committee's opinion, a few necessary first steps toward meeting the immediate crisis and setting the stage for establishment of a long-range federal science policy that will obviate future crises.

SUMMARY OF FINDINGS

1. American scientists and institutions of higher learning have been encouraged to depend heavily on federal grants for scientific research and development as part of their normal operating expenditures. Current and anticipated federal reductions require cutbacks in individual programs that range from the inconvenient to the catastrophic. In some cases, the effects of the institutions themselves are serious; the continued existence of some has been placed in doubt.

The loss of federal support in this area is having an adverse effect on the financial integrity of both state and privately supported schools. Ironically, this may accelerate the pressure for private academic institutions to obtain state support and for states to receive more federal support of higher education in general.

2. The effects of the scientific spending cutbacks are being felt particularly by those persons, institutions and programs that are not well established. New colleges, graduate centers and research conters are finding it difficult to attract first-rate scientists. Young scientists often find it virtually impossible to obtain funds for their work. New research ventures, in a broad spectrum of activities

from basic physics research to clinical medicine, are also having severe difficulties attracting support.

3. Cutbacks are leading to the loss of substantial investments already made by federal government and others. New schools, hospitals and research centers are not being fully utilized, research that is now reaching a fruitful stage will have to be discontinued, and experienced research teams are being disbanded with consequent permanent losses of important capabilities.

4. The future supply of scientists is being adversely affected. Training programs for both scientific and technical personnel are being cut back severely.

5. The pressing needs of our society, in many crucial areas, are failing to get the scientific attention they deserve. Potential solutions to such problems as poverty, racial discrimination, population control, air and water pollution, cancer and cardiovascular disease, mental illness, mass transportation, housing and education are not being pursued because of the lack of continuing support.

6. As a result of all these factors, morale in the scientific community is low. Many scientists and engineers in colleges, universities and research centers are disturbed by the effect of the cutback on their work. Preliminary soundings indicate that scientists in private industry are equally concerned.

SUMMARY OF RECOMMENDATIONS

1. The federal government should, at the earliest possible moment, take short-term corrective action to offset the critical short-term effects of the cutbacks.

2. Guidelines for the annual growth rate of federal spending on scientific research should be established. The growth of the economy can well sustain a rate of 15 to 20 percent per annum.

Such a policy, however, must be founded on our perception of the fact that existing programs do not now use available scientific knowledge and manpower to their fullest extent. (Ideally, spending on science should be defined by human needs—social, economic and cultural—and not by a fixed formula of growth rate.)

A case can be made for increasing scientific research expenditures at this time by 15 percent a year—first, because it is based on society's previous record of response to its many research needs, and second, because it will allow universities to balance research growth with that of graduate education.

3. Improved methods of consultation and communication should be established between the federal government and the scientific community, so that each can better understand the unique problems, pressures and challenges facing the other.

4. Since scientific research is generally a long-term process, every effort should be made to put the scientific research budget on a long-term multi-year basis.

II. Science as the Key to Social Evolution

> "Research . . . is supported not only to accomplish agency missions—usually as a forerunner to development—but also to increase the broad body of scientific and technical knowledge which underlies the future advancement of the Nation's welfare, economic growth, and security."
> —FEDERAL RESEARCH, DEVELOPMENT AND RELATED PROGRAMS, Special Analysis of the Budget of the United States Government for the fiscal year ending June 30, 1966.

The place of science in the fabric of society has not been, nor is it now, argued. There is a consensus so far-reaching that the Bureau of the Budget statement above may have been made by a statesman, an historian, an economist, a representative of the people, a scientist or the President of the United States.

In a memorandum to the heads of departments and agencies of September 13, 1965, President Johnson said that:

"A strong and vital educational system is an essential part of the Great Society. In building our national educational system, we must bear in mind all of the parts, and all of the levels—from Headstart for pre-school children to the most advanced university levels. At the apex of this educational pyramid, resting on the essential foundation provided for the lower levels, is the vital top segment where education and research become inseparable. The Federal Government has supported academic research in agriculture for over a half century and in the physical sciences, life sciences and engineering since World War II; the returns on this national investment have been immense."

A day later he noted in a statement to the Cabinet:

"Throughout the postwar years, it has been my abiding and actively supported conviction that the policies of this nation in support of the advance of science would have a decisive role in determining the extent to which we fulfill our potential as a nation—and a free society."

One of the major members of that Cabinet, former Secretary of Defense Robert S. McNamara, told Congress in 1968:

"We should be willing to give first priority in the R&D program to a reasonable, sustained level of research spending, taking into account the inevitable price and wage increases from year to year. During FY 65 to 68, after adjusting for inflation, research funding declined. It is quite clear we must now reverse this trend and support more vigorously many scientific figures that show great promise and clear relevance to our future security."

In remarks based on his policy paper "The Research Gap: Crisis in American Science and Technology," President-Elect Richard M. Nixon noted that:

"As we look back we find how much we owe to the creative power of science and technology for our steadily improving living standards, for the value of our money, for the defense of our country and for our prestige and influence in the world.

"As we look at the problems ahead—maintaining our national security, rebuilding our cities, fighting the erosion of our pay envelopes and pensions, extending our influence for peace in the world, in every realm—trained scientists and engineers are essential to progress.

"Scientific activity cannot be turned on and off like a faucet. The withdrawal of support disperses highly trained research teams, closes vital facilities, loses spin-off benefits and disrupts development momentum."

Representative Emilio Q. Daddario (D.–Conn.), concerned about the $100 million National Science Foundation budget cut recommended by the House, noted that the cut was particularly dangerous in view of the slashes in support for basic research being forced on mission-oriented agencies. Although it was obvious, he said, that the mushrooming of federal support of research in the 1950's and '60's couldn't be sustained, Congress's current economy wave may drop the support for basic research below the cost-of-living increases needed merely to stay even.

"It is essential that we policy makers not forget the lessons of the past on the importance of being in the vanguard of basic science," said Daddario. "When the chips are down we are not going to pull any rabbits out of the scientific hat without knowing the basic tricks."

Pleading for restoration of the $90 million cut from the National Science Foundation's appropriation request, Senator Fred R. Harris (D.–Okla.) told the Senate:

"I realize, as do the other Members of this body, the need to effect a reduction in the Federal budget at this particular time. I am not convinced, however, that it makes much sense in the long run to reduce our support for basic science research for short run economies. Basic research, as it clearly implies, is basic to all advances that we have made and can ultimately make in such fields as physics, chemisty, biology, the social sciences, and other fields of science which underlie the tremendous technological revolution that this country has undergone since World War II. And I would remind Senators of the inextricable relationship of technological advance and innovation to our economic well-being."

In a chapter called "A Congressman's Perspective" from *Science and the University* (edited by Boyd R. Keenan), Representative John Brademas (D.–Ind.) wrote:

". . . let me observe that I think it is now widely recognized that scientists and engineers and their research and development activities played a crucial part in winning World War II. But today scientists and engineers are increasingly recognized by the public generally and by politiicans in particular as essential to winning the future. For only in recent years has the country come to accept the critical role that scientists and technicians play in economic growth, the health and well-being of our people and in the overall strength of our nation."

Richard T. Gill, Harvard University economist, writing in *Economic Development: Past and Present*, calls technological progress—

"perhaps the greatest single distinguishing characteristic of the modern age. It is by now commonplace that technology is revolutionizing our lives. Through new techniques and methods of production, an economy is enabled to produce commodities at a fraction of their former cost in terms of the amount of land, labor, and capital devoted to their production. Equally significantly, technology con-

stantly brings forth a flood of new products which no amount of effort and resources could have produced in the past.

"Technological progress . . . depends, of course, on applied science and ultimately on pure science. Abstract speculations on the nature of the universe, motivated originally by the simple desire to know and understand, will often later come to roost in some practical appliance which reduces labor or provides for hitherto unsuspected needs. In a certain sense, the 'scientific attitude' is at the root of the whole thing. The notion of a rational and comprehensible universe, of natural laws which can be apprehended and manipulated, of systematic, objective methods which can be used to unlock nature's secrets—this kind of approach is by no means a necessary or universal one, and, in fact, was the product of a long process of intellectual evolution in the Western World."

The relationship of science to economics is reiterated in an article in *The Goal of Economic Growth* (edited by Edmund S. Phelps), called "Research and Economic Growth" by Rand economists Benton F. Massell and Richard R. Nelson:

"How does research contribute to technical change? In one sense, by increasing and enriching our stock of knowledge. There are many difficulties connected with defining the stock of knowledge. Certainly it involves, much more than formal scientific knowledge, and research is by no means the sole activity by which knowledge is increased. Indeed, writers who use as their examples the inventions of the 18th and 19th centuries have tended to argue that formal scientific knowledge is unimportant to inventors—what is important is general technological knowledge.

"However, writers who have used as their examples the more recent advances in chemical and electronic technology have argued that, though formal science may not have been particularly important in the more distant past, it has played a more major role in recent inventive activity."

The President's Council of Economic Advisers noted in their 1962 report that:

"The advance of technological knowledge depends on the amount and effectiveness of the human and material resources devoted to research and development . . . Research and development cover a wide range of activities aimed at increasing the stock of scientific and technical knowledge. As we move from basic research to applied research and to development, the goals become more closely defined in terms of specific practical objectives, the predictability of the results increase, and the benefits become less diffuse. More than 90 percent of research and development spending is for applied research and development—most of it for development. Slightly less than 10 percent is for basic research.

"And contrary to common belief, less than one-third of all basic research is done by industry. Government, the universities and other nonprofit institutions, although doing only one-fourth of total research, do most of the Nation's basic research. Such research seldom results directly or immediately in new products and processes. But in the long run, basic research is the key to important advances in technology."

Finally, scientists themselves are eloquently aware of their responsibilities to human welfare and progress.

Said Dr. Bentley Glass, academic vice president, The State University of New York at Stony Brooks, New York, at the Academy's June 30 town meeting on The Crisis Facing American Science:

"It is easy indeed for the legislature that wishes to preach economy to point to dozens of scientific researches supported by federal grants or contracts that have no obvious practical results, and the titles of these can be, and have been, readily held up to ridicule . . . I suggest that the right way to consider whether the support of basic science is profitable to the nation is to examine the enterprise in reverse. Look at the great developments in our modern world . . . that make 1968 already more different from 1900 than 1900 was different from the year one. Tell us which one of these is not solidly based on the growing structure of scientific knowledge accumulated by many men."

Nobel Laureate Albert Szent-Gyorgyi suggests that:

"Three points should be made clear. One is that our whole industry and national defense are based on basic or fundamental research. However, fundamental discoveries need a few years till they bear fruits for everyday life. It follows that basic research can be cut out altogether without any immediate effects but once it is cut out industry will crumble within a few years . . . equally true, also for national defense, which is no longer fought with clubs but with atomic energy and computers.

"The second point which has to be made clear is that we owe not only the agreeable and high level of our life to science and fundamental research but

we owe our very lives to it. (It) has extended the expectancy of human life by two decades. So if we enjoy life longer now, owning to past research, it is our moral duty to continue this research and pay off by providing for future generations.

"The third point . . . is that once basic research is hurt the damage is very difficult to repair. Owing to the present budget cuts very many gifted youngsters, people who are designed to be future leaders of research, will be channeled into other areas and it will take a whole generation to fill the gap."

III. The Effects of Cutbacks in Federal Support of Science

1. *Federal reductions are causing cutbacks in individual programs that range from the inconvenient to the catastrophic. In some cases, the effect on the institutions themselves is serious.*[1]

The data in Table 1 indicate why reductions in federal expenditures have so upset the academic community. In academic year 1967–68, the federal government paid almost one-fourth of all the expenditures on higher education. The figure was just under 20 percent for publicly controlled schools and slightly more than 30 percent for independent schools.

These federal funds have helped our colleges and universities rise to educational and scientific preeminence. Any significant reduction in federal funding will naturally have a great effect on the financial viability of many schools.

TABLE 1.—EXPENDITURES ON PUBLIC AND PRIVATE INSTITUTIONS OF HIGHER EDUCATION ACADEMIC YEAR 1967–68

[In billions of dollars]

Source of expenditure	Control of school: Public	Control of school: Private
Federal Government	2.1	2.3
State government	4.1	.1
Local government	.4	
All other	4.1	5.2
Total	10.7	7.6

2. *The effects of the scientific spending cutbacks are being felt particularly by those persons, institutions and programs that are not well established.*[2]

Federal cutbacks, both real and threatened, have had one of their most detrimental effects on the coming generation of scientists, who are faced with the almost insurmountable problem of finding support for the research work with which they hope to prove themselves. Recognizing this, the House Subcommittee on Labor, Health, Education and Welfare made this statement in its report on the Fiscal Year 1969 budget:

"The committee also expects that special consideration will be given to young scientists who are now emerging from the research training and fellowship programs. It would obviously undermine the purpose of the federal investment in these programs if the young men and women whose training was supported were now to be denied the support that will enable them to put their training to use."

What is true of new scientists is also true of new institutions. In this regard, new medical schools face one of the most critical situations. Spurred by a nationwide need for more physicians and with tacit promises of large-scale federal support that would enable them to expand and improve medical education and research, these schools have been counting on federal assistance. The spending cutback means that government support has fallen far short of both hopes and needs.

The same situation prevails in other fields of science. Groups and programs that have been getting federal support for years find it easier to have at least most of that support continued than do new projects seeking a share of a declining total budget.

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[1] For documentation, see Appendix I.
[2] For documentation, see Appendix II.

3. *Cutbacks at established institutions are leading to the loss of substantial investments already made by the federal government and others.*[3]

The essence of scientific research is continuity. This has become especially true in recent years, as the nature of the information sought in research has become more complex. Increasingly complex equipment must be set up and mastered; scientists of different skills must be brought together and formed into a team; technicians must be trained to support the scientists' work. In many disciplines, the fruits of this effort are not forthcoming until many years have been invested.

The disruption of this process by the sudden withdrawal of financial support can be disastrous. By breaking up a research team, the results of several years of effort and spending can be negated. Once dispersed, such teams are difficult to reassemble.

What is true of people is true of institutions. The physical and organizational setting for research must be set up before the research can begin. At this time, a number of colleges find themselves with buildings and programs that cannot be utilized because of the reductions in federal spending. The result is waste and underutilization of facilities and people. Signs of this waste now are evident throughout the United States, as documented in replies to the Academy's survey.

4. *The future supply of scientists is being adversely affected.*[4]

This is, in part, a corollary of point 3; with less money going to younger people, the number of scientific personnel that are being trained inevitably will drop. Some of this is visible, but a good deal of it is not. Science has no guaranteed supply of the best minds of its generation. The sciences compete for these minds, on the basis of the intellectual challenge and opportunity for fulfillment that they offer. A failure to give the sciences proper support inevitably results in a reduction in the number of students who feel that a life in sciences is desirable.

Scientists can point to the number of applicants who have been turned away, but they cannot cite those students who did not apply because there was little to attract them. These losses are insidious, but their effects can be serious. Science and technology today provide the sinews of greatness. The nation that fails to attract the best people to these fields finds itself falling behind. The United States today attracts scientific talent from all over the world; a good deal of our success in the world has been due to this attraction. But the key to success is the home-grown scientist.

In the years since World War II, the United States has moved from a secondary role to the leading spot in world scientific education, with schools and graduates that are second to none. We have come to take this ascendancy for granted, forgetting that it took the upheaval of a world war and an unprecedented period of growth to make it possible. It would be difficult to undo that achievement, but no achievement is permanent in today's world. Replies to the Academy's survey indicated that many scientists are concerned with the future supply of talent in light of the budget reductions.

5. *The pressing needs of our society, in such fields as medicine, environmental health and urban affairs, are failing to get the scientific attention they deserve.*[5]

With thousands of Americans dying prematurely each year of cardiovascular diseases, the survival rates in many forms of cancer leveling off and such diseases as tuberculosis, syphillis, cholera, even small pox continuing to decimate the populations of underdeveloped countries, the need for spending more on medical research and clinical care is obvious.

Other needs of our society have been more recently recognized but are no less obvious. The air of our cities is noxious, our waters are poisoned, and biologists are expressing growing concern about the effects of all of man's activities on the natural world.

All these needs are pressing. The most pressing is for the information necessary to mount an intelligent attack against man's natural enemies and the enemies he has created for himself.

Comments received by the Academy give ample evidence that there is no shortage of dedicated scientists and physicians anxious to grapple with these problems. The comments also give evidence that many of them find themselves frustrated by cutbacks that are crippling or eliminating crucial work. The range of work covered by these comments extends across the full spectrum of problems faced by our modern industrialized society. The comments indicate that the money saved by withdrawing support from this research will be spent more painfully later to repair the deficiencies that the research might have prevented.

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[3] For documentation, see Appendix III.
[4] For documentation, see Appendix IV.
[5] For documentation, see Appendix V.

6. *As a result of all these factors, morale in the scientific community is low.*[6] It would hardly be surprising to find that many scientists are disturbed by the conditions they now face. The majority of the scientific community is aware that no economic or societal activity can forever grow faster than the aggregate national income. And since the support for science has, over the past two decades, been growing faster, the day has come when the growth of scientific support must level off so as not to overtake all other activities. But the cuts experienced have come too soon and too suddenly, in particular those blanket cuts imposed by the National Science Foundation and the National Institutes of Health.

Most scientists are responsible people who do recognize the need for careful scrutiny of expenditures. Few, however, can regard such a dramatic change with equanamity. In addition to their personal concerns, they are concerned with the future of science itself. To see a nation willingly relinquish a position of leadership achieved by an almost unprecedented effort is not easy. To see the careers of promising young men and women marred at the outset is disturbing. To see years of research painfully brought to the brink of fruition only to be abandoned for lack of money is distressing.

The replies to the Academy indicate only a small part of the personal turmoil that has been caused by the cutback in support for American science. These comments illustrate pointedly the human price being paid because of those cuts. There are more organized arguments for reversing the recent trend, but none are more striking.

IV. A Proposed Science Program

1. *Short-term emergency actions*

The Academy's survey indicates what the short-term effects of the cutbacks in federal support of science are and will be. In light of these responses and of past experience, the Ad Hoc Committee on Evaluation of Federal Support of Science view three crucial problem areas as demanding immediate emergency consideration:

(*a*) The training of scientific manpower to preclude a serious shortage in the near future, a crippling one within five years.

(*b*) The continuation of support of ongoing projects of merit.

(*c*) The granting of funds to programs involving new concepts and ideas.

The Ad Hoc Committee also takes the liberty of recommending for consideration two temporary sources of funds to help alleviate the three problem areas described above.

The clearest source of such funds appears to be appropriations earmarked for capital expenditures. Such diversion of capital funds should, however, be viewed as strictly emergent and temporary, with deficiencies to be made up as necessary in the 1970 budget. Long-term reliance on such a measure can only further impede scientific progress by curtailing the number and quality of scientific facilities.

The committee further suggests that the fastest and most effective way to get these diverted funds to the sources of greatest need may be to increase general grants to institutions with the stipulation that the additional grants be used to meet the three needs specified above.

A second source of immediate funding for endangered scientific areas might also lie within government agencies themselves which, given the maximum permissible discretionary authority, could divert appropriations from unendangered, well-funded programs to those crucial programs currently foundering for lack of support.

2. *The emerging manpower problem*

In general, the more funds allocated to research and development activities, the higher the employment of research and development engineers and scientists will be. On the other hand, less spending on research and development work will tend to lower the stock of trained manpower.

Prediction of the future employment of research scientists and engineers at various levels of research and development spending is not particularly difficult. For example, with prices constant, a 10 percent increase in such expenditures would result in a 10 percent employment increase for scientific personnel. Conversely, a 6 percent price and salary rise in face of the 10 percent increase in expenditures for scientific activities would result in an employment increase of only 4 percent.

[6] For documentation, see Appendix VI.

Based on the empirical record, we can make reasonable forecasts of the future course of (a) prices related to the employment of scientific manpower and (b) the expenditure of the non-federal government sector on research activities. Therefore, by assuming various levels of federal expenditures, forecasts can be made of the employment of scientific manpower. The results of such calculations are shown in this section. They indicate that cutbacks of the amount currently in effect can catastrophically affect the availability of scientific manpower.

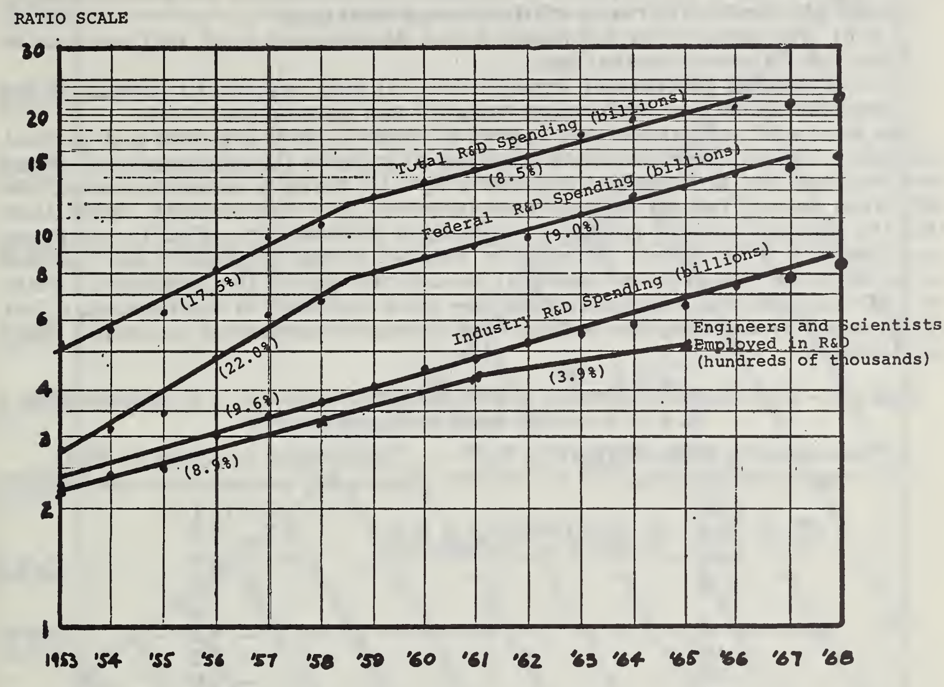

FIGURE 1

RESEARCH AND DEVELOPMENT SPENDING AND EMPLOYMENT

Source: NSF 67-7
(See Appendix vii for tabulated data)

Figure 1 is intended to give a capsule view of the course of research and development spending and the employment of scientific manpower since 1954.[7] The data are plotted on a ratio scale to indicate growth rates—on a ratio scale the slope of a linear trend indicates the rate of growth.

From 1954 to 1958, total research and development spending increased at a 17.5 percent rate. Subsequently the growth rate declined to 8.5 percent. This decline was not due to any significant variation in the pattern of industry's expenditures on research and development. Such spending has advanced at a rather consistent 9.6 percent rate since 1954. It was caused by a cutback in the growth of federal support for research and development activities. In the earlier period these federal expenditures increased at a 22.0 percent rate and later the rate declined to 9.0 percent.

Since federal expenditures have tended to comprise almost two-thirds of the total spending on research and development activities, the effect was to decrease significantly the growth in the employment of research and development engineers and scientists. In the 1954–1961 period their employment rose at an 8.9 percent annual rate. More recently that rate declined to 3.9 percent.

A crude price index for engineering/scientific research and development services can be obtained from the NSF data on employment and expenditures. These data show that the annual total cost of employing an engineer/scientist was $24,000, $32,300, $33,800, and $40,700 in 1954, 1958, 1961 and 1965 respectively. This

[7] Data have come largely from publications of the National Science Foundation. Sources, data, and data problems are presented in Appendix VII.

represents a 4.6 percent average annual increase in the research and development price index over the 1954–1965 period. (More recently inflationary pressures have probably increased this rate.)

The empirical record outlined above forms the foundation for our forecasts of the effects of variations in federal government research and development spending on the magnitude of the stock of engineers with research and development skills. Our assumptions are that:

(*a*) Research and development expenditures outside of the federal government will continue to rise at a 9.6 percent annual rate.

(*b*) The price index for research and development work will continue to rise at a 4.6 percent annual rate.

(*c*) Federal government expenditures initially support 63 percent of the scientific manpower performing research and development work.

The results of our calculations appear in Table 2. Note first that a 20 percent increase in federal expenditures is expected to increase the employment of scientific research and development manpower by 11.1 percent. Actually, during the 1953–1958 period, federal expenditures increased at a rate slightly higher than this (22 percent) and the resultant employment increased at a slightly lower rate (8.9 percent). This modest discrepancy between actual experience and forecast is probably ascribable to the fact that during that period the government share of R&D expenditures was somewhat lower than that used in our forecast, a fact that tended to decrease the influence of federal expenditures on overall R&D employment.

TABLE 2.—*The effects of changes in Federal Government R. & D. spending on R. & D. scientific manpower employment*

The change in Federal R&D spending (percent)	The change in scientific R&D manpower employment (percent)
+20	+11.1
+15	+ 7.8
+10	+ 4.8
+ 5	+ 2.0
0	− 1.2
− 5	− 4.4
−10	− 7.2
−15	− 9.8
−20	−13.1

NOTE.—Assumptions : See text.

Now, to consider the spending figures that seem to reflect best the effects of the recent cutback. In the Fiscal Year 1969 Budget Message, a 4.2 percent increase in R&D spending over fiscal year 1968 was proposed. Since then, however, major cuts in the budget have been mandated, and it is now estimated that federal expenditures on research and development will be about 15 percent less than in FY 1968. Table 2 shows that such a reduction will cause a 10 percent decrease in scientific manpower employment—a decrease of some consequence.

Another question arises: What are the manpower implications *over time* if government R&D spending is kept constant? Again, it is assumed that non-federal R&D expenditures will continue to rise by 9.6 percent annually, and that R&D costs continue to go up by 4.6 percent annually. It is further assumed that federal spending remains at the 1968 level. The results of these circumstances are compared with the 3.9 percent increase in scientific and engineering manpower that occurred in the 1961–65 period. See Table 3 and Figure 2.

TABLE 3.—THE R. & D. SCIENTIFIC MANPOWER GAP

Year	R. & D. supply of scientists and engineers: Projected at 3.9 percent annual growth	R. & D. supply of scientists and engineers: Estimated with Government spending constant at fiscal year 1968 level	Manpower gap	Percent of projected
1968	565, 000	565, 000		
1969	587, 000	558, 000	29, 000	4.9
1970	610, 000	552, 000	58, 000	9.5
1971	634, 000	547, 000	87, 000	13.7
1972	659, 000	543, 000	116, 000	17.6

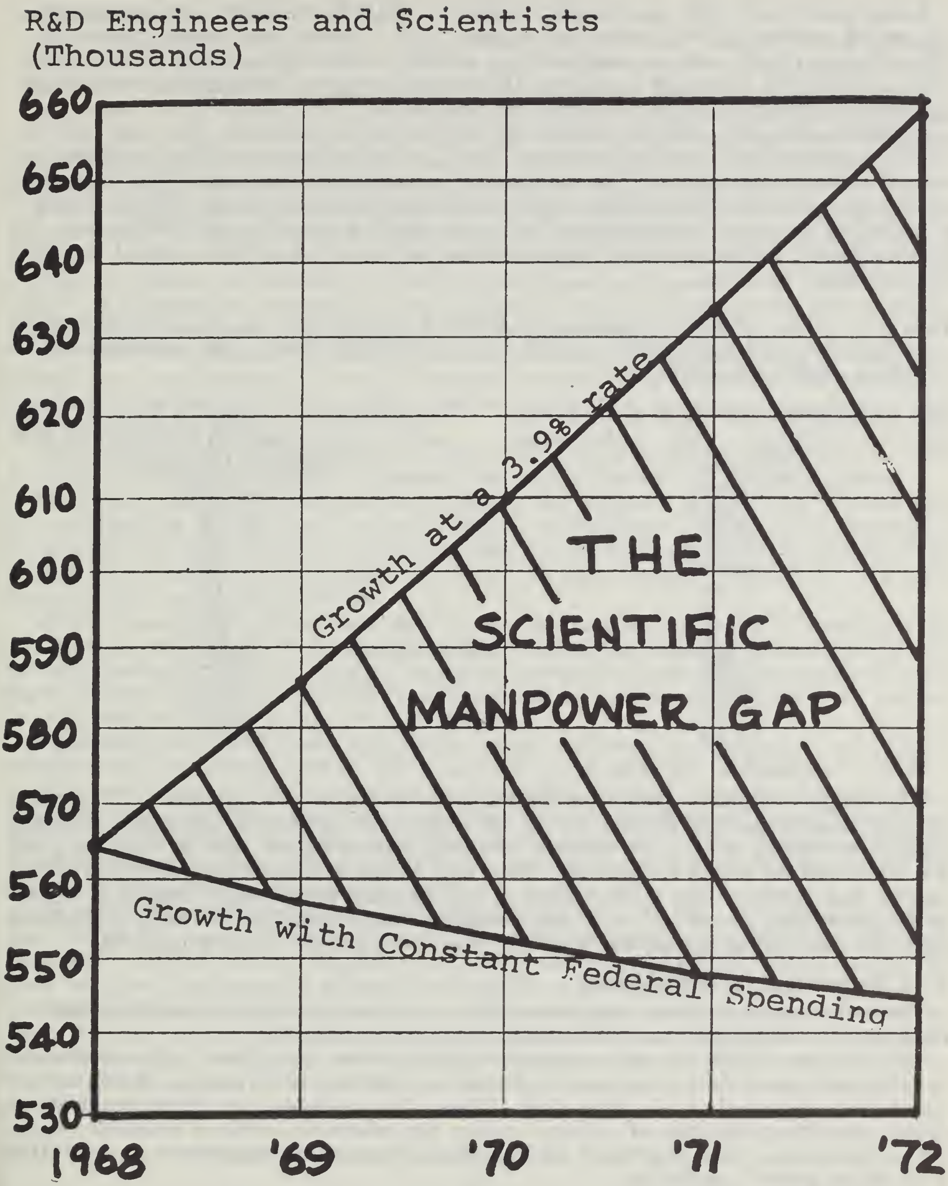

FIGURE 2

THE SCIENTIFIC MANPOWER GAP

Assumptions: See text

At the end of one year, at a 3.9 percent growth rate, one would expect to find 587,000 scientists and engineers working in research and development. But if federal spending is held constant at the 1968 level, only 558,000 would be so employed. In only one year, a gap of 29,000 engineers and scientists would develop.

After four years, the gap would widen to 116,000 scientists and engineers—almost 18 percent of the projected supply. (We suggest that comparison with a 3.9 percent growth rate in manpower is rather conservative since, in the 1950s, when the growth rate was 6 percent, there were constant complaints about shortages of skilled scientific and engineering manpower.)

Colleges and universities would be hit even harder than the rest of the research community for two reasons. First, a larger share of the academic research spending is paid for by the federal government. Second, it appears that academic research will be hit by larger cutbacks than other R&D efforts. Table 4 is based on the same calculations that were used in the above predictions—a 9.6 percent yearly increase in non-federal spending and a 4.6 percent annual increase in the cost of research.

TABLE 4. —*The effects of changes in Federal Government R. & D. expenditures in colleges and universities on R. & D. scientific manpower employment in colleges and universities*

The changes in federal R. & D. spending in colleges and universities (percent)	The change in scientific R. & D. manpower employment in colleges and universities (percent)
+25	+16.8
+20	+12.8
+15	+ 9.0
+10	+ 5.0
+ 5	+ 1.3
0	− 2.6
− 5	− 6.3
−10	−10.2
−15	−14.0
−20	−17.9
−25	−21.7

NOTE.—Assumptions : See text.

The budget originally proposed for FY 1969 envisaged an increase of 13 percent in academic research funds. If, as now appears probable, academic funding suffers a cutback of 20 to 25 percent of the proposed figure, the net cutback from FY 1968 will be about 10 percent. This will cause a 10 percent reduction in research and development employment in colleges and universities. Again, it can be anticipated that the effects on young scientists and engineers will be crushing and that the increasing manpower gap will soon be a source of deep concern.

3. A long-term growth guideline

Instead of talking about manpower gaps, we should be talking about growth—that growth required to meet the manifold needs of mankind.

But it is one thing to state a general philosophical principle, quite another to specify and quantify a program to attain the desired goal. Yet men of affairs are constantly required to do just that. Thus, for example, we have established rather specific guidelines of national policy for tolerable levels of unemployment, wage increases, price increases and growth. It is no more difficult to establish a scientific growth guideline.

In a democratic society, guidelines are not evolved from thin air, but frequently arise from a crudely formed consensus. We have had our economic policy dominated by a broadly felt desire to maintain the unemployment rate below the 4 percent level and this has become virtually the definition of "full employment." Since the 1890s, with the exception of the 1930s, our economy has undergone a mild inflation. Simultaneously we have experienced a fairly consistent tendency for the standards of living to advance. These traditional patterns are the basis from which we have formed goals of price stability and economic growth. There are also some rather well established tendencies relevent to scientific research and these should serve as the basic of a science policy.

Scientific research plays a crucial role in forming the character of our educational process—a process involving close to 60 million full-time students and teachers.

The fruits of scientific research are pervasive throughout this entire system. They are, however, most closely related to that portion of the system concerned with graduate education. If the quality of such education is to be maintained, the

proportion of graduate education resources allocated to scientific research must be maintained.

In establishing the graduate education growth rate, society has implicitly established a general guideline for the growth of scientific research activities. Otherwise, the balance of educational progess, as we know it, will be upset.

A number of different standards can be used to measure the graduate education growth rate: new entrants, total students, full-time students, master's degrees awarded, doctorates awarded, and so on. All of these, however, are tied closely together; and, it develops, all show rather similar rates of increase.

For example, in the decade starting 1955–56, master's degrees awarded in the physical and life sciences and engineering increased by 10 percent annually. All master's degrees increased 9.6 percent annually over the same period, while physical science doctorates increased by 11.1 percent annually in 1960–67. The Office of Education forecasts a 9.1 percent annual growth rate for master's degrees in science and engineering in the decade ending 1974–75.

We can then take a 10 percent increase in graduate education in the next decade or so. Adjusting for the expected increase in costs, one can conclude that a 15 percent annual growth in federal research spending is needed to balance this growth rate.

This rate of spending increase is precisely the growth rate suggested by Dr. Donald D. Hornig, President Johnson's science advisory. Dr. Hornig states:

"We have more students coming in. They are already in the high schools and the elementary schools and, as the number of students grows, if we are going to provide the same research opportunities, we are going to have to increase the investment, and an approximate 15 percent per year for some years to come would seem to be a reasonable target."

The recommended 15 percent growth guideline also compares favorably with the past record. In 1958–63, federal expenditures for basic research grew by 22 percent annually. More recently the growth rate has been slightly above 15 percent. Clearly this is the rate of growth needed to sustain the required expansion in our research and development activities.

Numbers and guidelines frequently mask essence. Accordingly, we should consider the previously quoted statement of Dr. Albert Szent-Gyorgyi:

"We owe not only the agreeableness and high level of our life to science and fundamental research, but we owe our very lives to fundamental research, which has, in recent times, extended the expectancy of human life by two decades. Our forebears paid for this research and it is our moral duty to make similar advances for the welfare of future generations."

Thus, within the span of this century, 40 percent has been added to the average man's life span. What indeed is the value of such a contribution? Does it amount to 40 percent of the gross national product—some $300 billion per year? And what is the value of scientific research and development when we add on the fantastic increase in the quality of life that has also taken place since the turn of the century? Dr. Szent-Gyorgyi suggest we, as beneficiaries of progress caused by the labors of our fathers, have a responsibility to transmit a better world to our children. Indeed, is not this close to the raison d'etre of a civilized society?

Appendices: Documentation of Findings

Appendix I

Federal reductions are causing cutbacks in individual programs that range from the inconvenient to the catastrophic. In some cases, the effect on the institutions themselves is serious.

"The situation for the current fiscal year is very difficult. Reduced appropriations, coupled with the additional reductions . . . have meant that funds obligated morally (and in the case of the NSF contractually) have been withdrawn. Because members of our faculty who supervise research projects have already made commitments based on the original funding level, it is clear that serious dislocations can be expected. We shall have to reduce every NSF-supported project to approximately 75 percent of the expected levels. We shall have to reduce the number of people engaged in this work, and the rate of completion will accordingly drop. Among other consequences of the sudden reductions this year, the efficiency with which remaining funds are used must fall, since in many cases they must be used to meet on-going commitments to people who will have insufficient funds to work efficiently."—*Yale University, New Haven, Conn.*

"This summer there were at least 12 faculty members who had expected support which did not appear. They continued to work throughout the summer without supplemental pay, but it was not a satisfactory situation. Also, in the coming year there will be from 10 to 20 research fellows whose federal support did not materialize and who will have to be carried by emergency funds of the University."—*University of Delaware, Newark, Del.*

"We are now in the position that most private institutions find themselves of absolute dependence upon the federal government for a substantial portion of our operating budget. Even a minimum cutback of the present level of support would result in serious consequences to many facets of our program."—*University of Southern California, School of Dentistry.*

"We have always been concerned about possible reductions in federal support for scientific research and education and have attempted to be prepared to meet such emergencies if they arise. However, the expenditure reductions now being levied . . . come at a very difficult time in terms of regular support from other sources. Practically all state supported universities have recently experienced restrictions in appropriations from state legislatures."—*Purdue University, Lafayette, Ind.*

"In reviewing our summary information on outside support over the past two fiscal years, I find the university contribution toward total project costs of federally sponsored programs was increased by 10 percent to 37.6 percent of the total project costs. This is the result of greater stress on the part of the government for cost sharing. This demand puts an added burden on state appropriated funds, and makes less available for other critical university needs."—*University of Iowa, Iowa City.*

"The hardest hit area is medicine, but engineering and physics have also suffered. A rough estimate indicates that 50 percent of the approved but not funded projects are in basic research, 20 percent in applied research, 14 percent in graduate education, 12 percent in undergraduate education, and 4 percent other.

"The effects of these federal cutbacks is to force us to the very brink of catastrophe; to diminish our effectiveness as a private midwestern university; and to negate the efforts producing the rise to excellence of the last five years."
—*Washington University, St. Louis, Mo.*

"I think it is most unfortunate that the reduction of federal support of research and training in the American universities is coming at this precise time. As you probably know, this is a time when, with the exception of some 12 or 13 top-level private universities, the private universities that have carried and made such great contributions to American higher education are in serious financial difficulty. The competition with heavily-financed state institutions is everywhere creating grave difficulties, and the need for some infusion of public support grows every day. I am afraid that the present cuts in funding are hastening the decline and perhaps the disappearance of all but a few of the private universities of this country. I would consider this a tragic blow to our educational system."
—*St. Louis University, St. Louis, Mo.*

"The School of Public Health of the University of Texas at Houston is still an embryo, and our concern with the curtailment of federal support programs are more with still birth than with reductions in scope of programs. . . . Our rate of growth is heavily dependent upon the availability of federal support."—*School of Public Health at Houston, The University of Texas.*

"Thus far the most serious cutback in the current fiscal year has recently come from NSF. Whereas the total training and training research and development grants amount to $991,681, NSF has notified us that we may spend $311,000 in fiscal '69. . . . As yet, we do not know how we can reduce our expenditures by two-thirds in the current year.

"Should other agencies send us similar notices we would be indeed critically hampered in carrying on our undergraduate, graduate and research programs."
—*Clark University, Worchester, Mass.*

APPENDIX II

The effects of the cutbacks are being felt particularly by those persons, institutions and programs that are not well established

"It has been our experience up to this time that funds continue to flow to large, established ongoing projects conducted by groups of senior scientists. The pinch is being felt by the smaller projects involving the research of a professor and several graduate students. If the research for which funds are sought is new rather than a continuing project, support is much more difficult to obtain. The difficulty is still greater in cases where the research proposal is initiated by a junior member of the faculty who has not yet established his reputation.

"Indeed, the most disturbing consequence of the cutbacks up to this time is that young scientists just entering the profession—graduate students, post-doctorals and junior faculty—are being deprived of support through reductions in federal fellowship and trainee programs and in federal sponsorship of small research projects at just the time in their careers when they most need support. This seems to us to have the most serious implications for the future."—*Columbia University, New York.*

"Whatever reductions are made should not inadvertently reduce the training of young scientists, notably at the predoctoral stage, but also at the post-doctoral as well. These training activities are the basic ingredient of the trained manpower for science of the future and are commonly embodied in the grants to investigators of the small science category as well as in formal established training programs."—*University of Wisconsin Medical Center, Madison, Wis.*

"Currently, two remodeling projects are under way with approval of the federal agency, but without federal funding. There is no certainty that these will be funded. . . . Furthermore, our request for Office of Education Title I and Title II support for the new engineering building . . . and the new life sciences building . . . definitely has been delayed."—*University of Nebraska, The Graduate College, Lincoln, Nebr.*

"This is one of the new schools of medicine under active development in the United States and is beginning its first academic program with the academic year of 1968–69 . . . The greatest impact of this curtailment has been in faculty recruitment. It is extremely difficult to convince quality scientists to leave an institution where they may have established programs in order to join a new faculty without reasonable assurance that support for research and research training will be made available . . . In one week at the beginning of August, I was informed of eight separate project grant applications submitted by this faculty that had been approved but were not to be funded because of curtailment of funds."—*University of Texas Medical School at San Antonio.*

"To date, reduced federal funding in research seems to have affected the new investigator more than the experienced and well-funded research persons. There is some evidence that new and unfunded investigators have been so discouraged by the publicity on reduced funding that they have decided it is a waste of time to submit applications."—*University of Missouri, Columbia, Mo.*

"It is quite clear . . . that the hardest hit will be new faculty members who are struggling to establish their research programs."—*University of Nebraska, Lincoln, Nebr.*

"Our greatest concern is with the enforced curtailment of new programs. New entries into the field of scientific research, particularly at the assistant professor level, are experiencing great difficulty in attracting federal funds. We are reserving our meager institutional funds for this purpose when possible.

"There is, of course, an element of healthfulness in being forced to provide good administration and, in periodic episodes spaced far enough apart, it should be beneficial. If it continues too long its good effects will be far offset by the irreparable damage to programs, to careers, and to the futures of thousands of budding young scientists."—*University of California at Davis.*

The problem of institutions is no less pressing:

"First, NSF is putting a ceiling on the total amount of its funds that the university may expend, regardless of the total amount of money NSF has awarded

to us for the year. Second, we are just starting a very large building program which could be disastrously hit by any large-scale cutback."—*Rutgers—The State University, New Brunswick, N.J.*

"It should be remembered at the outset that the College of Human Medicine, like all new medical schools founded during the past few years in the United States, has been established with the understanding that a firm federal commitment to resolving the severe medical manpower shortage had been made. From the standpoint of a new medical school, in order of importance, the following commitments have existed: First, matching construction funds; second, project and improvement grants designed to fund medical schools for education and as educational institutions, rather than through the 'back door' of research grants; third, research grants.

"According to available figures, the amount by which the College of Human Medicine has been cut, including construction, project and research grants, is $3,269,697. The deadening effects of such cuts on a new institution is extraordinarily serious, and if continued, could be lethal."—*Michigan State University College of Human Medicine, East Lansing, Mich.*

APPENDIX III

Cutbacks at established institutions are leading to the loss of substantial investments already made by the federal government and others.

"The Georgia Institute of Technology is a relative newcomer to the field of graduate education at the Doctoral level. We have made our greatest gains within the last decade and are on the threshold of entering into a period of well-planned expansion of the graduate division which will surpass all past efforts in this direction . . . The reduction of federal support threatens this entire program and if it is carried out to the extent we anticipate may well cause us to forego implementation of this expansion and devote our resources to maintaining the degree of excellence we have already achieved."—*Georgia Institute of Technology, Atlanta, Ga.*

"I am a young scientist and have spent the last five years establishing a laboratory and my position in it only to have to face the possibility of having to abandon academic science altogether because of lack of support. I might add that I was trained for academic science at considerable cost to the U.S. Government as an NIH fellow. I might also add that abandonment of animal colonies and equipment into which enormous effort and sizable sums of money have been invested represents the falseest kind of economy imaginable."—*Research Laboratories, Albert Einstein Medical Center.*

"It appears to me that the decision to make massive cuts in the budgets of scientifically oriented government agencies is very shortsighted and will result in the breakup of many functioning research teams. It seems remarkable that, at a time when Ex-President Eisenhower is suffering from a serious heart condition, the funds available for research on heart muscle are being cut back so drastically."—*University of Pennsylvania School of Veterinary Medicine, Philadelphia, Pa.*

". . . if the cutbacks continue, we will undo much of the good we have so arduously and carefully built up during the past fifteen years; all that we will be doing with our cutbacks will be to move personnel from productive endeavor to the welfare roles."—*New York University College of Dentistry, New York City.*

"Research in psychiatry has been definitely slowed by the reduction in federal support. For example, a five-year social psychiatry investigation of mental health services and need in the south which was approved by the NIMH Council has not been funded. For this project, even though financial support may be forthcoming, the delay has resulted in the breaking up of experienced research teams. Obviously, in the long run, this is expensive because both time and effort are always involved in extensive recruitment of qualified personnel."—*University of Florida, College of Medicine.*

"Cutbacks in federal support of research have been disastrous to the Child Research Council research in healthy growth, development and adapation of human subjects through the life span. They produced limitation of activities to

ongoing studies in 1964, elimination of psychological investigations in 1964, elimination of psychological investigations in 1965, and complete curtailment of data collection in 1967. Our present activities are limited to analyses of existing data in the selected areas of physical growth, nutritional intake, and health records under a contract with NICHD. Not only are we unable to continue the study of our subjects but also we are forced to restrict the areas of data we include in analyses by reason of inability to pay staff. Since the Child Research Council is the only program which has engaged continuously in the study of human biology in healthy subjects long enough to have a sizable population (over 100 subjects) who have been studied from birth to termination of the program when true live-cycle studies are half complete is lacking in foresight. To abandon the study population that has given cooperation for 37 years is to invite having to repeat the whole process at a later date.

"The Child Research Council is unable to meet the demands of life-span conclusions about man in less than the life span of one generation of subjects. The value of such studies to the understanding of the processes of aging, the insights into the natural history of degenerative disorders, and the adaptive patterns that produce a successful and health man are manifest. Support for one program not directed to correction of specific disorders does not seem out of reason in our present economic state. The fact remains that the depression economy of the 1930's supported this and several similar programs. Present support for such research is possible only through federal sources, and cutbacks promise its extinction."—*Child Research Council, Department of Pediatrics, University of Colorado Medical Center.*

"In April of 1963, we received a grant from NASA for graduate student traineeships to initiate a program of study and research which was associated with the establishment of a Space Science Center on our campus. The University hoped for and expected NASA support in three areas for this program: (1) continuing support for the predoctoral traineeships; (2) a grant covering at least a major portion of the cost of a building to house the Space Science Center; and (3) a sustaining grant to support faculty and graduate student research in a manner which would encourage the interdisciplinary aspects of the program—the real purpose and function of the Space Science Center.

"The traineeships grants started in 1963 and rose to approximately the intended level of about 30 students, by supporting 32 students in academic year 1966/67 and held at 30 in 1967/68. We have NASA funds to support only 20 students, however, this coming academic year, 8 students in 1969/70, and the traineeship program is currently scheduled to be completely phased out after 1969/70. The University received a grant of $1 million in August, 1965, to defray part of the cost of constructing a new building to house the research programs of the Space Science Center. The $2.326 building is now under construction with the additional funds provided from the University's recent capital fund campaign, and occupance is expected in about six months from now. The University applied in February 1968, to NASA for a sustaining grant to support research programs of faculty and students in the Space Science Center. NASA responded that they would not be able to fund such a grant . . .

"The University does not have the resources to carry the program and other governmental agencies, faced with the same sort of budget cuts as NASA, are not likely to provide even a portion of the needed support. Industrial support is even more improbable. The situation is clearly one in which we have launched a program and constructed associated facilities and just when the program should begin to hit stride, support is withdrawn."—*The University of Rochester College of Engineering & Applied Science, New York.*

"The university of Missouri recently completed a ten year master plan which contained a sizeable capital improvement program . . . (including) a new School of Medicine, development of two new metropolitan area campuses, replacement of inadequate structures, expanding enrollments and new academic and research programs. The legislature is now considering a bond program that would permit rapid accelleration of the construction plans. As substantial portions of the capital improvement costs are planned to be met by federal funding, shortage of funds at the federal level would materially prolong the timing of this program and would work a real hardship on all four campuses."—*University of Missouri, Columbia, Mo.*

" . . . the current cutback in federal support of scientific research has resulted in the loss of two biochemists and a third when one of our grants terminates in February of 1969. These men hold doctoral degrees and have been part of our research team organized 15 years ago. Our work has been in the field of blood coagulation, fat metabolism and vascular disease and more than 95 percent of our support has come from federal agencies. One chemist is lost to us but the other two might be retained if an immediate reversal of policy by the Congress were to occur. One grant has been approved but not funded. Another grant is in process at the present time."—*Chicago, Ill.*

"My clinical research program of problems of liver disease of infants and children was supported by the National Institute of Arthritis and Metabolic Diseases from April 1, 1961, to August 31, 1966.

". . . Investigation of unusual liver problems from such metabolic point of view was possible and we were able to start collecting samples of liver tissue from . . . infants with metabolic problems for electron microscopy. Renewal of our project was refused and aid for an electron microscopist was denied. Since that time we have not been able to process or study these 50 biopsy specimens which we had already collected and our research has been inadequately supported by the small gifts from our patients and their friends.

"It is impossible to maintain good technical staff on a short-term basis, and much time has been wasted in retraining personnel to carry out difficult enzyme assays. It is obvious from the attempts made to interest private foundations in support that they are being deluged with requests and must spread themselves very thin. Time and effort, at the minimum one complete month per year, is expended in trying to get support for further studies. This is in an area of pediatric research which has *not* been oversubscribed and where genetic counselling and laboratory aid is necessary."—*College of Physicians and Surgeons, Columbia University, New York City.*

"Our subsidiary, Geoscience Incorporated in Cambridge, Mass., has been engaged in geophysical research for government agencies. We had a staff of about fifty. Our area of interest was geophysics, and we had built up a research competence in instrumentation, computer applications, theoretical analysis, and field experimentation. In the past two years, support for this group has been spotty, although previously we had been able to carry forward a number of projects on a continuous basis. The group has remained together but presently we are faced with what appears to be a complete lack of support from federal sources. Although the group is only 30 percent supported by federal funds, this is still a serious drop in funding, and the group may well disperse due to a consequent drop in size. Geoscience is a unique organization in that it is solely devoted to geophyscal-geological research. We feel that we had contributions to make in the fields of undersea communications, mine detection, tunnel detection, resources evaluation, pollution control, and in certain areas of oceanographic data gathering. I feel that we are in serious danger of dispersing this group and losing their capabilities."—*Ray Geophysical Division, Mandrel Industries, Inc., Houston, Tex.*

"At Vanderbilt, the fields of (a) Humanities, (b) Social Sciences and (c) Engineering appear to be in for the worst retrenchment. The first two of these have just started long-term growth; cut backs will be serious. The proposed cutbacks will leave our School of Engineering in a most unsatisfactory condition of partial growth into its potential as a center-of-excellence in the Mid-South."—*Vanderbilt University, Nashville, Tenn.*

APPENDIX IV

The pressing needs of our society, in such fields as medicine, environmental health and urban affairs, are failing to get the scientific attention they deserve

"The Institute of Laryngology and Voice Disorders represents the major biomedical research center in the U.S. for interdisciplinary studies of human communications . . . The greatest damage in our research program occurred in the area of applied research, where the freezing of promised Federal funds delayed indefinitely the clinical development and testing of a new, simple acoustic device for mass screening and the early detection of laryngeal disease. The basic research of this important development was finished two years ago, and

funds are urgently needed to complete the equipment design and to refine the computer techniques on the basis of larger clinical studies."—*University of Southern California, Los Angeles, Calif.*

"We have a research oriented faculty that is experienced at aggressively seeking expansion of investigative efforts. Aside from the effects of any cuts, the present funding situation does not allow the type of growth that we feel we are capable of and that is in the national health interest."—*Vanderbilt University, Nashville, Tenn.*

"I have conducted a program of experimental chemotherapy of trophoblastic diseases at Northwestern University Medical School since 1962. Our results with such therapy have been excellent. We have treated 153 patients. In patients with choriocarcinoma without metastasis, our permanent remission rate is 98% . . . Our program is now curtailed because of two specific reasons. The amount of federal grants, which have been used for this program, is now reduced to the extent that we can hospitalize only 30% of those previously hospitalized. The increased cost of hospitalization has further reduced the number of patients we can hospitalize through these grants to . . . only 25 percent of the former number."—*Passavant Memorial Hospital, Chicago, Ill.*

"We have an active research program in clinical pharmacology of cancer chemotherapeutic agents under a contract with the National Cancer Institute. The purpose of this program is to study the physiological disposition of agents useful clinically in the treatment of cancer, with a view to elucidate their mechanism of action, so that not only more efficacious agents may be synthesized, but also more sufferings will be alleviated and more patients will be cured . . . The projected cut of 15 percent in this year's budget will most adversely set back our program. The long term effect of this fund reduction will definitely be irreparable. I shudder at the thought that, as a result of the Administration's near-sightedness, thousands of cancer patients will have to suffer unnecessarily in ever-increasing numbers."—*M. D. Anderson Hospital & Tumor Institute at Houston, Tex.*

"Our present research program on the treatment of hemorrhagic shock has suffered by the cancellation of any Army support grant of approximately $30,000 yearly. This support has been carried out over a six-year period. Our NIH Support grant, which we have held for some 8 years, likewise has not been renewed, resulting in a total loss of approximately $65,000 yearly to this research effort. Needless to say, our efforts in this area are at a complete standstill and will continue to be so until further fnnds are obtained."—*University of Kentucky, Lexington, Ky.*

"It appears that it may be difficult to enter such fields as transportation and urban and economic development, where the college has some competency and a desire to get programs under way."—*Michigan State University, East Lansing, Mich.*

"For what it is worth, I have been completely unable to obtain any financial support from the NIH for work which I consider to be most important concerning the effects of oral contraceptives on copper and ascorbic acid metabolism. This is most regrettable as this work is concerned with the problem of thromboembolism in women taking the pill and I would have thought it worthy of support."—*State University of New York College of Medicine, Brooklyn.*

"In steadily growing areas like the Division of Health Affairs at Chapel Hill (the Schools of Medicine, Nursing, Public Health, Dentistry and Pharmacy), planned developments of extended programs in teaching, research and public service have been slowed by decreasing funding."—*The University of North Carolina.*

"By this year we can document federal funding cuts in basic research areas in nearly every department of the school and virtually no new grants have been awarded . . . The research programs in infectious disease, cardiac research and cardiovascular surgical research, hematopathology, cancer pathology, microbiology, anatomy, and pulmonary disease have been cut back in varying degrees for lack of funding . . . A large pulmonary disease research program has suffered heavily in cutbacks—there are enough patients equipment and experimental designs for productive work, but no funds. Graduate education has suffered training grant cutbacks in diabetes, biochemistry, cardiology, etc. If the large block grants, planning grants and program grants are seriously cut or eliminated our

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medical school will find itself with a large and carefully selected student body, a successful completed building program to accommodate teaching and research, a dwindling faculty and a decimated research program."—*University of Southern California School of Medicine.*

"Requests (and demands for engagement in the urban crises) can hardly be satisfied without substantial funds to support new programs designed to aid in the resolution of this pressing concern."—*Temple University, Philadelphia, Pa.*

APPENDIX V

The future supply of scientists is being adversely affected

"I am part of a unit with ten professional staff . . . solely devoted to research and development in laboratory medicine. Federal funds largely support this effort. We are, I believe, the only unit of its kind in the country. We operate within a university department of pathology. The need for laboratory tests applying the new ideas and techniques developed in other sciences to solving the problems of the bedside practice of medicine, particularly to the care of cancer patients is widely recognized. "To date, cutbacks in our direct support have not been too serious, although recently a moratorium on the purchases of any new equipment has severely curtailed planned new developments in the unit. More serious, however, is the drastic cutback in training grants, our own was not renewed, and as a result, we are no longer able to support professional personnel while training them in the use of the newer techniques and exposing them to the newer laboratory ideas. This is particularly serious as it comes at a time of rapid expansion in the use of mechanization of analyses and general automation in laboratory operation involving a much higher degree of professional competence than hitherto."—*Bellaire, Tex.*

"The expansion of our Chemistry and Geophysics Depts., along with qualitative improvements and the evolution of new programs of research, has been adversely affected by cutbacks in funding for Title II of the Higher Education Facilities Act and for the National Science Foundation's Graduate Research Program. The social sciences and the humanities have long been the undersupported areas of American higher education, and Boston College shares the need for additional support in these areas for both basic and applied research . . ."—*Boston College.*

"The cutbacks and particularly the uncertainty of "reasonable support" based on careful budget projection has made it extremely difficult to assure research fellowship candidates of the training they desire in the Lung Station (Tufts) at the Boston City Hospital. These young investigators will be the backbone of departments devoted to the management of patients with pulmonary disease in our communities and medical schools. It is not only essential but, indeed critical that they can be assured of training without threats of disrupted budgets. The prime deficit of the failing heart is oxygen; and, in this instance, Congress is the prime deficit in our "failing" programs."—*Tufts University School of Medicine, Boston, Mass.*

"The graduate student body will be 25% lower than planned because we shall not have stipend support from grants or fellowships support for the full number."—*University of Southern California, Los Angeles, Calif.*

"After a rapid survey of the effect of federal cutbacks on research and service manpower pools, we discovered widespread reductions in fellowships, and a markedly reduced rate of new starts in training. A new fund saving mechanism introduced this year is the request to the principal investigator to reduce his current budget. The minimum request is 10% and many investigators are asked to make 15 to 20% reductions. Many graduate students are left without support as research grants carry funds for research assistants which must be cut. Training grants for the coming year carry fewer stipends for graduate students. In both training and research grants we feel an obligation to use the limited funds available to support the students now in training. Thus, there is a dramatic reduction in support for the group of students who would normally enter training this year. Some training programs have been cut out totally and many are deferred until funds become available. The NASA traineeships program has been closed down completely for 1969. NDEA IV trainees were cut in half from 88 new

trainees in fiscal 1968 to 45 new ones in 1969 at Wisconsin. The NIH has maintained its predoctoral fellowships; but to do so has cut back on postdoctorals. NSF has warned us to expect a 15% cut in current year support.

"The 15% cut . . . is estimated to remove support for 500 to 700 graduate students including about 200 in areas supported by HEW." If major delay in release of funding is enforced by the Bureau of the Budget this year as is now threatened, even greater disruption of Health Manpower Training will occur because of lack of funds to start new students in graduate training."—*The University of Wisconsin Graduate School, Madison.*

"Our greatest concern is with the enforced curtailment of new programs. New entries into the field of scientific research, principally at the assistant professor level, are experiencing great difficulty in attracting federal funds. We are reserving our meager institutional funds for this purpose when possible.

"There is, of course, an element of healthfulness in being forced to provide good administration and, in periodic episodes spaced far enough apart, it should be beneficial. If it continues too long its good effects will be far offset by the irreparable damage to programs, to careers, and to the futures of thousands of budding young scientists."—*University of California, Davis.*

"Federal cutbacks in funds for basic science research programs and training programs will adversely influence the number of talented people who will be available for teaching basic medical science in the years to come. At the very time that the federal government seeks to increase the number of professional schools and expand the size of existing ones in the United States, we are confronted with diminishing financial resources to adequately train a greater number of persons needed to staff such new facilities."—*Louisiana State University Medical Center, New Orleans.*

"Some of us feel that if the nation wishes to push the education of more physicians, it will have to realize that research is part of such an educational program. We (also) have a training program, the express purpose of which is to train individuals to enter the public health and medical laboratory field. With the expansion of federal medical programs such as Medicare, such individuals who have received good training will be at a premium . . . The cutback in funds for education has prevented the continuance of this program. The question arises as to what trained personnel will be available to operate the expanded programs of medical care."—*Baylor University College of Medicine, Houston, Tex.*

"The primary effect on our research . . . has been to limit our support of graduate students and postdoctoral fellows. This, of course, may seriously affect our contribution to research in the future, if such support is permanently curtailed, since our graduate departments in the sciences are of stellar quality.

"It must be admitted, however, that the loss of some federal support has not been totally deleterious; the care with which we have had to allocate resources and plan research has forced us to determine our directions of advance very consciously."—*Brandeis University, Waltham, Mass.*

APPENDIX VI

As a result of all these factors, morale in the scientific community is at a low ebb

"With uncertainties as to what my 1969 budget is going to be I am left with considerable anguish to say the least in making personnel commitments. When a good man writes me for instance asking for a fellowship, all I can tell him is to come until Christmas time and then perhaps go on relief or unemployment insurance after that."—*Drexel Institute of Technology, Philadelphia, Pa.*

"This gradual attrition is stifling the initiative and creativeness of many of our younger faculty members because of an inability to even receive seed money for their basic research. On an institutional scale it is my opinion that the same mental suffocation is likely to occur if we are unable to initiate new and imaginative programs of academic excellence because of these threatened reductions."—*Georgia Institute of Technology, Atlanta, Ga.*

"At the University of Southern California, and particularly within the biomedical sciences area, lack of federal funds for research during the last few years has produced an appalling drop in morale; loss of promising teach-research-

ers to industry, hospitals, and other institutions; and has nearly wrecked certain graduate programs, such as the Biochemistry Program, which has lost its bid for renewal of a training grant to support graduate students in biochemistry."—*Allan Hancock Foundation, University of Southern California.*

"When graduate students and candidates for graduate school realize the difficulties that faculty have in obtaining support for their research, it cannot help but dampen their enthusiasm for remaining in basic science or for entering such basic sciences programs, knowing that the future for them might be equally dim . . . The basic scientist who enjoys his teaching responsibilities is a more effective educator if he can simultaneously introduce his students to the mechanisms by which new information in his discipline are discovered."—*Louisiana State University Medical Center, New Orleans.*

". . . we are increasingly concerned about the implications of cuts in federal support of research and education. We are especially aware of this problem because we are in a second year of stringent state budgets, which have included a 10% reduction in state funding of organized research . . .

". . . our cut in the state budget resulted in serious reductions in level of effort in cancer research, computer research and services, biomedical engineering, mining engineering, traffic and transportation engineering, management and labor relations research, and seismological studies. We have been forced to delay or seriously undersupport new programs in legal research and in the relation of law and society, urban and social studies, research on animal behavior, earthquake engineering, and higher education."—*University of California, Berkeley.*

"Our laboratory is investigating the biological effects of low level pesticide exposure in an intact mammalian system. The proposed cutback in federal support will mean that our efforts will be severely curtailed. Our major need is in current expense money and maintenance of personnel. We can continue our research efforts without additional major equipment even though this means postponement of some experiments. We feel that the cutback in funds for established laboratories is a very serious matter. Especially when one is concerned with environmental toxicants which continue to be used and to accumulate in the environment irrespective of wars (military, social, political and economic)."—*College of Veterinary Medicine, Iowa State University of Science and Technology, Ames, Iowa.*

"The biochemical research laboratory is staffed by one full-time research scientist, myself, and several technicians. My task is to write grants and obtain support for projects of interest to the clinical staff. The work in the past has been focused on inhibiting tumor growth by restricting essential amino acids in the diet, and on the influence of diet and hormones on fetal development.

"The former project has had some promising results on both human and mouse tumors. A 3 year grant application was recently returned, with a budget reduction of about two-thirds, with the one-third portion that was approved not funded . . . I do not believe that the work done here will remain unfinished, in view of the interest shown by investigators in other laboratories, but the lack of research support will certainly remove me from the field of cancer research."—*The University of Chicago, Chicago, Ill.*

APPENDIX VII. RESEARCH AND DEVELOPMENT EXPENDITURES AND EMPLOYMENT

The data upon which our manpower forecasts are based came mainly from the National Science Foundation (NSF) publications (1) "National Patterns of Research and Development Resources, Funds, and Manpower in the United States," NSF 67–7; (2) "Prospective Manpower Situation for Scientific and Engineering Staff in Universities and Colleges, 1965–1975." NSF 67–11; and (3) various issues of "Reviews of Data on Science Resources." All trends have been approximated by the conventional least squares technique.

It is noteworthy that the NSF data on federal government research and development expenditures differ somewhat from information published by the Bureau of the Budget. (This can be seen by comparing the figures in NSF 67–7 with those in "Special Analysis J; Federal Research, Development, and Related Programs," Bureau of the Budget, January 1968. These data appear in table vii–2 of this appendix.) We have chosen to use the NSF data for two reasons. First, their data are not limited to federal government expenditures but also include non-federal government expenditures and research and development

employment. The additional information is vital to our analysis. Second, the NSF data are slightly less favorable to our argument. They imply a lower rate of increase in the price level for research and development work. Since we are suggesting that government expenditures must take cognizance of increasing prices, this choice of data causes a downward bias in our proposed government expenditure guideline.

TABLE VII-1.—SCIENTISTS AND ENGINEERS EMPLOYED IN RESEARCH AND DEVELOPMENT BY SECTOR, SELECTED YEARS

[In thousands]

Sector	1954	1958	1961	1965
Total	237.0	336.0	429.6	503.6
Federal Government	37.6	50.2	55.1	69.0
Industry	164.1	236.1	312.0	351.2
Universities and colleges	30.0	42.5	51.7	66.0
(Universities and colleges proper)	(25.0)	(33.9)	(42.7)	(54.9)
Other nonprofit	5.3	7.2	10.8	17.4

Source: NSF 67-7.

TABLE VII-2.—SOURCES OF FUNDS BY SECTOR, USED FOR RESEARCH AND DEVELOPMENT, 1953-68

[In billions of dollars]

	Total	Federal Government (NSF data)	Industry	Universities and colleges	Other nonprofit	Federal Government (budget Bureau data)
Year:						
1953	5.21	2.75	2.24	0.15	0.07	
1954	5.73	3.13	2.37	.17	.07	3.15
1955	6.27	3.49	2.51	.19	.08	3.31
1956	8.17	4.84	3.04	.20	.09	3.45
1957	9.90	6.10	3.46	.23	.10	4.46
1958	10.85	6.77	3.70	.26	.13	4.99
1959	12.52	8.04	4.06	.29	.14	5.80
1960	13.71	8.72	4.51	.33	.15	7.74
1961	14.50	9.22	4.75	.37	.17	9.28
1962	15.61	9.89	5.12	.42	.19	10.37
1963	17.35	11.22	5.45	.49	.20	11.99
1964	19.18	12.53	5.88	.56	.21	14.69
1965 (preliminary)	20.47	13.07	6.53	.64	.23	14.88
1966 (estimated)	22.22	14.07	7.21	.70	.24	16.00
1967 (forecast)	23.80	14.93	7.87	.75	.25	16.72
1968 (forecast)	25.00	15.56	8.33	.84	.27	16.52

Sources: All data from NSF 67-7 except for final column which is from Bureau of the Budget "Special Analysis J," January 1968.

TABLE VII-3.—SOURCES OF FUNDS FOR BASIC RESEARCH

[In millions of dollars]

	Total	Federal Government	Industry	Universities and colleges	Nonprofit
Year:					
1953	488	233	148	73	34
1954	546	(1)	(1)	85	37
1955	608	(1)	(1)	99	43
1956	744	(1)	(1)	116	50
1957	854	404	256	136	58
1958	975	462	282	159	72
1959	1,157	613	280	185	79
1960	1,326	691	331	215	89
1961	1,540	843	350	250	97
1962	1,881	1,094	382	293	112
1963	2,202	1,323	414	343	122
1964	2,566	1,606	425	402	133
1965 (preliminary)	2,926	1,851	457	473	145
1966 (estimate)	3,233	2,049	497	530	157

[1] Not available.

Source: NSF 67-7.

30-553—69——12

[From the Bulletin of the Atomic Scientists, December 1968]

Strategic Balance and the ABM

(By Franklin A. Long)

Many uncertainties plague the strategic balance among nations. However, the added problems which will confront the United States and the Soviet Union as a consequence of antiballistic missile deployment will also have a strong impact on Europe: The immediate question for the nonnuclear West European countries will be whether to go nuclear or not. The overriding priority which the two superpowers give to their own security will cause a drastic weakening of the current Nato and Warsaw Pact alliance. Where then, and how, will Europe find its own security? F. A. Long is vice-president for Research and Advanced Studies at Cornell University.

Uncertainty characterizes all aspects of strategic balance among nations but it is particularly characteristic of the weapons systems that are incorporated into modern military forces. There are several reasons for this. A prime cause of uncertainty is the rapid rate of technological change. This makes it hard to be sure that a given military posture is currently optimal. It even makes it difficult to ascertain when a weapon, or a strategy for its use, has become obsolete. Equally, the rapid rate of technological change makes it difficult to anticipate the trends in weapons or their effectiveness.

A second cause of uncertainty, which also stems from the growth of technology, is the wide spectrum of system choices and weapons designs available to the planner. One can emphasize artillery, or unguided rockets, or aerial bombardment; one can give strategic nuclear responsibility to submarine-launched missile forces, to silo-launched missiles; one can even consider assigning strategic deterrence to the biological weapons systems.

A third source of uncertainty is the enormous complexity of modern weapons systems, combined with the frequent requirement for very rapid response. Modern airplanes are themselves very complex and require elaborate maintenance systems to keep them in a state of readiness; response time for their use is, however, usually a matter of hours. Rocket-borne nuclear weapons systems are fully as complex, yet, at least for land-based missile forces, their command and control must permit response times within tens of minutes.

It is virtually unavoidable that very real uncertainty will exist as to whether these complex and infrequently used systems will in fact respond rapidly, and will perform reliably in the very small reaction times that can characterize emergencies. Realistic proof tests of these weapons are exceedingly difficult to accomplish, it being especially hard to analyze the spectrum of possible emergencies and then simulate them appropriately. For ballistic missile defense systems, proof testing is further inhibited by the provision of the Moscow Treaty which bans nuclear weapons testing in the atmosphere. Thus large uncertainty will remain.

The question, then, is, in view of these uncertainties, what will be the probable impact of antiballistic missile (ABM) deployment on the strategic balance which now exists in the world? Since the emphasis will be on the nuclear balance some comments on the current situation are in order.

Mutual Deterrence

For some years the principal component in the world-wide strategic balance has been the mutual nuclear deterrence which exists between the United States and the Soviet Union. This deterrence principally involves large forces of rocket-borne nuclear armed intercontinental missiles which are either housed in underground missile silos or are mounted on sea-going vessels. Target accuracy is probably in the order of one mile at the extreme ranges of from 5,000 to 10,000 miles. Equipped with, for example, one-megaton warheads this accuracy is sufficient to give a high probability that a targeted city will be hit and suffer very great damage. An important characteristic of the nuclear deterrent systems is that on each side the combinations of missile numbers and launch site vulnerability is such that enough missiles will survive a first strike to ensure vast destruction when they are used in a retaliatory second strike mode.

The existence of a continuing mutual deterrence depends partly on the fact that nuclear weapons, with their awesome capacity for death and destruction,

appear to be superior weapons for retaliatory use but inferior ones for political and diplomatic use. This low effectiveness of nuclear weapons in political situations is particularly evident when two opposing nations have them. They are also of comparatively low political utility when a large nuclear armed nation opposes a small nonnuclear nation since the moral and psychological inhibitions against use of nuclear weapons remains high. Hence the political impact of a threat to use these weapons is not intolerably great and the pressures toward obtaining a first strike capability can be kept in bounds. At the same time the destructive capability, in a retaliatory strike, of a reasonably non-vulnerable nuclear weapons force is so tremendous that the deterrence value of the force can be high. Furthermore, subtle characteristics of the nuclear deterrence force are not important in maintaining its utility as a deterrent, and even numbers of weapons is of only moderate import if indeed only a retaliatory use is sensible. It has therefore been possible for the United States and the Soviet Union to speak of a "stable nuclear deterrence," implying that the uncertainty in the mutual assessment of each other's nuclear forces were not sufficient to lead either nation into major new military or political initiatives.

One can argue that much of this stability is only psychological, that is, not consistent with the technical facts; but even a psychologically based stability can be real and important. Do technical or other developments now seriously threaten this stability and, if so, what consequences are likely to follow?

TECHNICAL UNCERTAINTIES

Since the establishment of the current position of strategic balance has principally depended on the utilization of systems which stem directly from recent technical developments in nuclear weapons, in long-range rockets, and in rocket guidance, it is unreal not to expect threats to this balance to enter from further changes in technology. As a minimum one could expect bombs and rockets to become more efficient and guidance accuracy to improve. But since the efficacy of mutual deterrence has seemed rather insensitive to small changes of this character, this kind of evolution has not carried the air of a serious threat to stability. In contrast, however, the development of a truly effective defense against long-range ballistic missiles carries the potential of destroying the effectiveness of a nuclear retaliatory force and hence of seriously upsetting the strategic balance. Furthermore, it is highly doubtful whether a truly effective defense is even feasible: one runs the risk of weakening the strategic balance with no counterbalancing gained in individual nation security. It is in this context that the deployment of ballistic missile defenses (BMD) by the USSR and the projected deployment by the United States must be viewed.

Technically, a BMD system is highly complex. It involves nuclear-armed missiles with very short reaction times and a variety of highly sophisticated radars. The entire system is tightly linked to advanced computers which give the necessary speedy analysis and system control. Time for decision for the system is necessarily very short; only a very few minutes can elapse between initial radar detection and the launch of the defending forces if missile interception is to be successful. In view of these complexities and the tactical problems discussed below, there will necessarily be very great uncertainties in estimates of the reliability of a BMD system. The offensive forces arranged against a BMD system need to do their planning under the assumption that its reliability is high; the defenders, however, will probably make the conservative assumption that their own reliability is low, and hence tend to overbuild.

There will be even greater uncertainty in assessing the effectiveness of a BMD system since this depends on the properties of both the BMD system itself and the attacking forces. The attacker can equip his forces with decoys and other penetration aids in an effort to counter BMD. He can try to shield or otherwise modify his nuclear warheads so they can survive a BMD attack. He can modify his attack strategy in an attempt to saturate certain components of a BMD system or to induce nuclear blackout of the defending radars. The BMD designer can in turn respond to these various initiatives or to the threat of them. He may deploy more radars and ABMs; he may otherwise improve the system capabilities he may introduce a mixed system of short-range and long-range interceptors. The almost inescapable result of these possible activities is a high degree of uncertainty in the effectiveness of both the BMD system and the attacking missile system. Once again the probable response will be a "defense conservative" one. The BMD system group will be conservative in its assessment of the BMD effectiveness and will call for increased defense levels. Similarly the attacker will be conservative in his estimates of the effectiveness of his

countermeasures and will urge more offensive missiles and more penetration aids.

What are the consequences of these technical uncertainties? The one implied above is obvious enough: a strong pressure toward acceleration of the arms race. A reciprocal action-reaction behavior is inherent in the entire arms deployment business. But uncertainties of the type involved here will greatly exaggerate the problem.

A second consequence is changes in strategy and perhaps also in diplomacy.

A third and rather curious possible consequence of these technical uncertainties is a movement toward symmetry in miltary forces. If the USSR deploys ABMs, there will be a tendency of the United States to do the same. If the United States develops a Polaris system the pressures on the USSR to do likewise are very large. At first glance this trend toward duplicating systems is surprising, since, *a priori*, one might expect different local conditions, for example, land power versus sea power to lead the two nations in somewhat different directions. Actually the tendency toward duplication makes a certain amount of sense. Since the same science and much of the same technology are available to all each country can assume that, with earnest effort, it can develop whatever the other can. Hence the conservative procedure is to assume that whenever another country develops a given system it does so for technologically interesting reasons and that, therefore, it makes good sense to go down the same path. It is perhaps also true that the common worldwide growth in science, and to a lesser but inmportant extent in technology, causes opportunities for new weapons systems to become visible to the developed nations more or less simultaneously. Whatever the reasons the significant consequence is that by having systems of similar and mutually understood characteristics the uncertainty in analyzing their use and especially their deterrence features is reduced to an acceptable level.

STRATEGIC AND POLITICAL UNCERTAINTIES

The development of BMD systems and, in response, of penetration aid systems of various sorts will suggest a variety of strategic and political responses, many of which will be a direct consequence of the technical uncertainties. A minimum response will be a modification in the targeting of the nuclear deterrence forces. Assuming that the desire is to maintain some minimum level of assured destruction, it will be sensible to aim the deterrence missile forces toward less heavily defended targets. It may also appear persuasive to shift from direct attack of targets to indirect attack, by nuclear fallout, for example.

There will also be pressures for the procurement of new weapons systems in an attempt to maintain deterrence. Fractionally orbiting ballistic systems (FOBS) may be one such response. Very low-flying cruise missiles might be a second. A different and more perturbing possible consequence is that a strong BMD system may lead its possessor to contemplate a first strike with his nuclear missile forces. (Against this is the argument that a conservative posture will lead a nation to derogate its own BMD capabilities and hence be very hesitant to carry out programs which, for success, postulate a fully effective BMD.) Alternatively it has been argued that, with or without BMD, a nation which is vulnerable to a first strike can maintain deterrence by a dooms-day-like posture wherein it threatens to launch its entire missile force at the first instant of radar detection of a missile attack—that is, before its forces can be destroyed. It remains doubtful, as between the United States and the Soviet Union, whether threat of such an overwhelming response will carry the air of credibility that a deterrence posture seems to require. On the other hand this might be a much more plausible response to a superpower from a small power equipped with only a minimal force of nuclear delivery systems.

A very different, essentially political, response to a large BMD deployment is to shift to some degree the focus of deterrence forces from the principal enemy to its allies. Thus in response to a large American deployment of BMD, the USSR might increasingly direct its deterrence forces toward West Europe. It is not clear whether, on balance, this would be an effective strategy, since the effect would be to diminish the strength of all alliances to the superpowers.

An increase in military and political uncertainty arising from extensive BMD deployment and from the probable countermeasures to it could spell the end to the growth of any significant detente between the United States and the USSR. For a significant relaxation of tensions between two rival nations there must not only be clear perception of the mutual benefits of detente (and this does appear to exist) but a psychological climate which permits new foreign policy directions

and new peace-oriented bilateral arrangements to arise and gain acceptance. In a word, an atmosphere of trust must be developed. But it is just this mutual trust which tends to be the first victim of the uncertainties of an offensive-defensive arms race.

This problem is particularly acute in a country which, like the United States, relies on open discussions and debate to develop support for expensive or controversial projects. The kinds of argument which will almost of necessity be used to gain support for an expensive weapons system will very often be those which will raise suspicions of Soviet motives and in other ways work against the development of an atmosphere of trust and good will.

INCREASING THE PROBLEMS

The deployment of extensive BMD systems by the superpowers will almost surely increase the problems of obtaining significant arms control and disarmament. In a general sense, this is only a restatement of the conclusions that an atmosphere of uncertainty and suspicion is an almost inevitable concommitant of an arms race and that obtaining all forms of agreements will therefore become more difficult. But there are additional specific effects. In negotiating the proposed Nonproliferation Treaty it has steadily been pointed out that its acceptance by the nonnuclear nations is much less likely if an increased arms race is underway. And even if the treaty is widely accepted, its lifetime may be short if the current nuclear powers maintain or increase their reliance on nuclear weapons. As a further specific example, a comprehensive test ban will be much harder to obtain if large commitments to BMD systems are being made. Serious reliance on BMD carries with it strong pressures for continued underground testing of nuclear weapons to obtain new or modified weapons in response to changing requirements. Since pressures for "realistic" atmospheric nuclear tests will undoubtedly increase as BMD systems are developed, even the Partial Test-Ban Treaty may be jeopardized.

But assuming that the United States and the Soviet Union do begin serious negotiations toward a reversal of the nuclear arms buildup, the existence of extensive BMD will be a serious complication in obtaining agreements. As one works toward a freeze and cutback in nuclear weapons systems, the evaluation of the relative worth of different sorts and sizes of nuclear weapons carriers—ICBMs, MRBMs, or airplanes—will not be easy. In fact, there is good reason to believe that only very simple agreements will be negotiable. Consequently, the uncertainties of BMD deployment—uncertainties which relate both to the BMD systems themselves and the effectiveness of the missile forces which they counter—will most surely make the development of even a simple agreement more difficult.

IMPACT ON EUROPE

The added uncertainties which will confront the United States and the USSR as a consequence of extensive BMD deployment will have their impact on the European counties also. The principal stresses will probably enter in strategic and political spheres and long-range military planning.

The immediate problem for the nonnuclear West European nations will be whether to go nuclear, either for defense purposes or in an attempt to develop a viable deterrent force. Both paths offer serious technical problems and neither assures a force which will appear credible as a deterrent or a defense against either of the superpowers, unless it is done in an all-European context. Since the development of either type of nuclear force carries serious political risks—greatly increased military budgets and worsened relations with neighboring nations—it is doubtful whether there will be any rapid decisions to acquire nuclear forces. Over a longer time period, however, and in context of a continuing arms race, the pressures toward a political restructuring of European alliances and toward the development of some kinds of independent nuclear forces will probably be irresistible.

It appears almost inevitable that a continued U.S.-USSR arms race, with its clear implication that the two superpowers are giving an overriding priority to their own security, will cause a drastic weakening of the current Nato and Warsaw Pact alliance structure. Where and by what means the European nations would find their security is much less clear. One can hope that it might first be sought in a strengthened and invigorated United Nations rather than in a purely European context, but this too may be unreal in light of a continued U.S.-USSR arms race.

[From Science Magazine, Apr. 18, 1969]

Nixon and NSF: Politics Block Appointment of Long as Director

Political considerations appear to have blocked the appointment of Franklin A. Long, vice president for research and advanced studies at Cornell University, as the new director of the National Science Foundation. The vetoing of Long—who until last week seemed all but certain of the post—occurred at high levels in the Nixon administration. The stumbling block was apparently related to Long's liberal positions on arms control and disarmament, an issue which is currently of great concern to the administration but has no bearing on NSF. The incident is almost certain to cause an uproar in the scientific community, which regards the NSF job as "nonpolitical," and it is bound to exacerbate relations between Nixon and the academic world, which has never been very enthusiastic about the President anyway.

As recently as last Friday, 11 April, it appeared certain that the White House would name Long to succeed Leland J. Haworth, who will retire on 30 June after 6 years at the helm of NSF. Long was tentatively scheduled to meet with President Nixon that afternoon, and there were plans to announce his appointment to the press shortly afterward. Then, at the last minute, both the meeting and the announcement were canceled. Administration sources told *Science* that the cancellation was caused by a sudden change in the President's schedule. But this explanation is disputed by close friends of Long's.

One close associate of Long's, who was deeply distressed at the sudden turn of events, told *Science* unequivocally that "discussions between Long and the White House have terminated." The associate said the termination was caused by difficulties "of a political character" which are related to Long's involvement, officially and unofficially, in arms control and disarmament issues. The associate could not say precisely what issues were involved.

As far as can be determined, Long has not been among those scientists who have attacked the Nixon administration for its decision to deploy a "thin" ABM system—called "Safeguard"—to protect the nation's missile sites from surprise attack. Long told *Science* last week (before his appointment fell through) that he has taken no public stand on the Safeguard system and that he approved of the Nixon administration's seeming desire to hold arms limitation talks with the Russians. A colleague of Long's believes the White House may have been concerned about Long's liberal record on arms control in general, rather than about any specfic stand he has taken.

However, another source close to the incident said the blocking of Long was triggered by administration anger over an article of his which appeared in the December 1968 issue of the *Bulletin of the Atomic Scientists*, entitled "Strategic balance and the ABM." This article is not a particularly biting attack on ABM deployment and does not specifically criticize Nixon's ideas on the subject, which were not made public until after the article had been published. Long's article did, however, state that ABM deployment would be "a strong pressure toward acceleration of the arms race;" that it "could spell the end to the growth of any significant detente between the United States and the USSR;" and that it might jeopardize the partial test-ban treaty. It is perhaps understandable that Nixon might have second thoughts about appointing someone who had expressed reservations about ABM deployment, but sources close to the situation were upset at the idea that a man's views on military matters should disqualify him from the directorship of a purely civilian agency like the NSF.

For the past 6 or 7 years, Long has worked vigorously for arms control. In 1962 he became the first man to hold the post of assistant director for science and technology in the U.S. Arms Control and Disarmament Agency (ACDA), a position which gave him a key role in preparing and helping to negotiate the partial nuclear test-ban treaty with the Russians in 1963. He is also given major credit for building up the technical capability of ACDA. George W. Rathjens, Jr., of M.I.T., who served as Long's deputy at ACDA, rates Long as a "reasoned liberal" on arms control matters and says he was "the most vigorous advocate" among the key people at ACDA for moving ahead on arms limitations efforts.

Since leaving ACDA in 1963, Long has continued to work for arms control and for international cooperation by serving as a U.S. representative on the continuing committee for the Pugwash conferences, and by serving on the board of directors of the *Bulletin of the Atomic Scientists*.

Long's candidacy was probably not helped by his previous poltical activity

on behalf of the Democratic Party. Long is a registered Democrat who participated in the 1964 Scientists and Engineers for Johnson-Humphrey movement and who was listed as a member of Scientists and Engineers for Humphrey-Muskie in 1968. He told *Science* he has previously been registered as a Republican and as an Independent and is "not deeply" committed to any partisan viewpoint. Long's colleagues do not believe his political leanings provoked the White House to veto him, but the lack of a Republican record certainily didn't help him once questions were raised about his arms control views.

At this writing it is not clear precisely who was the key figure blocking Long's appointment. Long was among a small number of scientists nominated for the directorship by the National Science Board, the policy-making body for NSF. He is said to have been backed for the job by Lee A. DuBridge, the President's science adviser, but DuBridge was apparently overruled by White House political advisers or other key Republican powers.

Full details on the maneuvering could not be obtained before this article went to press. DuBridge and Long could not be reached for comment. And Philip Handler, chairman of the National Science Board, told *Science* he was "not at liberty to discuss the matter or disclose any details."

The blocking move was obviously of an abrupt and last-minute nature. Both Cornell University and the NSF had biographies of Long prepared for release to the press, and many members of the National Science Board were unaware as recently as last Monday that the appointment was off.

The blocking of Long is sure to cause fireworks in the scientific community, for many of the nation's leading scientists believe he would have made an outstanding director of NSF, an agency which will spend some $490 million this year in support of basic research and scientific education. Hans A. Bethe, Nobel prize-winning physicist and a colleague of Long's at Cornell, believes he would make "a strong head of that agency and push for lots of support." George B. Kistiakowsky, Harvard chemist and former science adviser to the late President Eisenhower, says Long would make a "first class NSF director whatever tasks I've seen him assume he has always done well." And Robert L. Sproull, provost at the University of Rochester and chairman of the Defense Science Board, believes Long has "outstanding attributes" that would make him a strong agency head.

Long has held a number of important scientific and advisory posts in the federal government. He served as a member of the President's Science Advisory Committee (PSAC) from 1961 to 1966, and has remained a consultant to PSAC and a member of its panel on space technology since then. Long chaired a PSAC committee then put out a landmark report in January 1967, entitled "The Space Program in the Post-Apollo period," and he participated in the official investigation of the fire that killed three astronauts in 1967.

Long has also contributed to military research in a number of ways. Colleagues say he chaired a PSAC panel on strategic weapons in the late 1950's, though membership on such panels is not made public; he has consulted for various Army and Air Force agencies; and during the Second World War, he served as a research supervisor in a National Defense Research Committee explosives laboratory in Pittsburgh, which was headed at one point by Kistiakowsky.

Long is said to possess a good understanding of the varied fields of science, and his own credentials as a physical chemist are impeccable. One eminent fellow chemist describes Long's work as "steady and very solid—not spectacular, Nobel Prize-type research, but fine research all the same." Long's research in kinetics, solution reactions, and other areas of physical chemistry won him election to the prestigious National Academy of Sciences in 1962.

NSF has seemed to be drifting for many months now—and the snafu over Long's appointment is not expected to improve matters. Several top posts have been left unfilled pending appointment of a new director, and the retrenchment caused by last year's budget cuts has slowed forward momentum. Prospects seemed to brighten earlier this year when President Nixon boosted NSF's spending ceiling by $10 million, took time out from his busy schedule to meet with the National Science Board, and indicated that NSF should play an "ever-increasing part" in the support of academic science. But the optimism and good will engendered by this high-level solicitousness may be disrupted by the Long incident. It took several years and an unpopular war to strain relations between the Johnson administration and the scientific and academic communities, but the Nixon administration may begin to detect a certain coolness in a matter of months.—*Philip M. Boffey.*

[From the Washington Post, Apr. 18, 1969]

Legislator Assails Veto of ABM Foe by Nixon

(By Victor Cohn)

Dr. Franklin A. Long was vetoed as National Science Foundation director after he spurned an Administration request to support it on anti-ballistic missiles, Rep. Emilio Q. Daddario (D-Conn.), House Science Subcommittee chairman, charged yesterday.

Both Long and the White House declined direct comment. But Long told an interviewer "political consideration" had arisen and "the alternatives available to me were unacceptable."

The decision to reject Long, it was learned, was made personally by President Nixon.

Daddario, whose subcommittee is NSF's House watchdog, said Long was "asked if he would agree to support" the Administration's ABM system and "when he refused to do so, he was advised that he could no longer be considered."

The charge by Daddario is certain to add to the wide dismay in science circles yesterday over what one professor called "President Nixon's effort to line up scientists by whether or not they support him on the ABM."

Long, Cornell University vice president for research and advanced studies, was at first summoned to Washington this month to be offered the directorship of the ordinarily placid NSF—an agency that supports basic research and graduate education and has nothing to do with warfare or weapons. It has traditionally been directed by scientists who political credentials have been regarded as irrelevant.

President Nixon's science adviser, Dr. Lee A. DuBridge, recommended Long. Then it was pointed out in Administration councils that Long authored an article last December expressing strong reservations about ABMs.

"On April 11, when I went to Washington," Long reported, "I found from Dr. DuBridge that the situation had changed and that new elements of a political nature relating to ABM had arisen." As a result, he said, "I was presented with a situation which I found unacceptable."

The immediate reaction in at least part of the scientific community was shock. Dr. I. I. Rabi, Columbia University physicist and a chief science adviser in the Eisenhower Administration—who happened to be attending a conference with Long yesterday at Brookhaven National Laboratory—said: "This is a kind of minor Oppenheimer case, where a man who was highly qualified was turned down because of a technical opinion on other matters. It already shows that we're in a bad way as far as freedom of thought and expression on scientific matters are concerned. That's the frightening thing."

Dr. George Kistiakowsky of Harvard, also a science adviser to President Eisenhower, said, "I am extremely disturbed and upset that ABM considerations" enter into picking the head of an agency "supposed to be above politics." Dr. Hans Bethe of Cornell—like Kistiakowsky, a strong ABM foe—called the incident "very sad."

A news report in Science, official organ of the American Association for the Advancement of Science, said it is "almost certain to cause an uproar" and "bound to exacerbate relations between Nixon and the academic world."

DuBridge, in an interview, declined comment on most of these matters. But he insisted that "the ABM is not a technical matter exclusively, but now a very hot political matter—a problem in international relations and arms talks and one now before Congress."

He said Mr. Nixon is pledged to build a more effective NSF and support basic science in general—and to this end did not cut NSF's $497-million 1970 budget request in the new budget revisions.

DuBridge and the National Science Board which oversees NSF now must seek another candidate to head the agency whose head, Dr. Leland Haworth, will retire July 1.

[From the New York Times, Apr. 19, 1969]

Biologists Score Nixon on Science—Say He Erred by Rejecting Long for U.S. Foundation

(By Harold M. Schmeck, Jr.)

Washington, April 18.—The governing body of the nation's largest biological science group has passed a resolution deploring President Nixon's decision against the appointment of Dr. Franklin A. Long to direct the National Science Foundation.

At his news conference today, the President conceded that he had decided against Dr. Long because of the scientist's views in opposition to the antiballistic missile system. Dr. Long, a physical chemist, is vice president for research and advanced studies at Cornell University.

Today at its annual meeting in Atlantic City, the board of the Federation of American Societies for Experimental Biology called the President's decision "unfortunate and in error."

The resolution said the board "considers this denial of Dr. Long's appointment to the N.S.F. directorship to be both unfortunate and in error and potentially serious in its long-term effects on American science in placing the National Science Foundation in the political arena where science does not properly belong."

"And further," said the board, "the federation wishes to reiterate and to emphasize the fact that the importance of the National Science Foundation to the nation's science and to the country as a whole demands that political considerations should not enter into the appointment of its director."

The resolution was made public by the federation's president, Dr. Edwin H. Lennette of the California State Department of Public Health in Berkeley. The federation's annual meeting is one of the scientific community's main public events of the year. Attendance at the meeting, which ended today, was set at 22,500.

Spokesmen for two of the nation's other major scientific groups, the American Association for the Advancement of Science and the American Institute of Physics, declined to comment on the President's decision.

Responding to a request for a comment, Dr. Donald F. Hornig, chief science adviser to the Johnson Administration, said he found the decision "deeply disturbing."

Dr. Hornig, vice president of the Eastman Kodak Company and professor of chemistry at the University of Rochester, said he was afraid the episode might make it much harder to find a director for the National Science Foundation.

Much the same concern was expressed here earlier by Representative Emilio Q. Daddario. Democrat of Conecticut, chairman of the House Science and Astronautics Committee's subcommittee on science, research and development.

"It is self-evident that recruiting a director for the National Science Foundation of the desired competence and ability and who will have the confidence of the scientific community, will now be extremely difficult, if not impossible," said Mr. Daddario.

[From the Washington Post, Apr. 19, 1969]

Nixon Promises All-Out Fight For ABM, Predicts Victory

(By Carroll Kilpatrick)

President Nixon said yesterday that he intended to wage an all-out fight for the Safeguard anti-ballistic missile system, and predicted that he would win.

He told a news conference that the controversial $6-billion defensive weapon which he proposed last month is "absolutely essential to the security of the country."

Despite the growing political and scientific opposition, the President gave no ground and served notice that he would debate his critics on the issue of national security. Safeguard, he said, is not a partisan issue.

He reported a substantial increase in Soviet missile and nuclear submarine strength and said that the only alternative to the ABM would be an increase in American offensive weapons to match the Soviet buildup.

At the same time, he frankly confirmed reports that Franklin A. Long, vice president for research and advanced studies at Cornell University, had been

denied appointment as director of the National Science Foundation because of his opposition to the ABM.

To have appointed "a man who quite honestly and quite sincerely—a man of eminent credentials, incidentally—disagreed with the Administration's position on a major matter of this sort" might have been misunderstood, the President said.

But his statement did not quell the uproar over the Long incident.

In Atlantic City, N.J., Edwin H. Lennette, president of the Federation of American Societies for Experimental Biology, charged that the Administration was playing politics in denying the post to Long. Lennette said that the rejection of Long was "both unfortunate and in error and potentially serious in its long-term effects on American science."

On Capital Hill, Sen. Edward M. Kennedy (D-Mass.) expressed "distress" over the denial of the job to Long, whom he called "an outstanding leader of the scientific community."

"The NSF is engaged solely in civilian, nonmilitary research," Kennedy said. "It will benefit no one if the apolitical status of the NSF is changed."

When the President was asked if he expected GOP Senators to support his ABM decision because he is a Republican President, he replied: "I certainly do not." He said his decision was not based on partisan consideration but on what he thought "best for the country."

The issue will "not be fought out on partisan lines," he said. When all the facts are known, "I am confident (the) decision will be in favor of the system," he asserted.

CREDIBILITY AT STAKE

An ABM system designed to safeguard America's missile bases, the President said, is necessary to protect the Nation's diplomatic and military credibility.

In view of the Soviet buildup, "I had to make basically a command decision as to what the United States should do if we were to avoid falling into a second-class or inferior position vis-a-vis the Soviet Union," Mr. Nixon said.

Moreover, he went on, by 1973 or 1974 Communist China will have "a significant nuclear capability which would make our diplomacy not credible in the Pacific unless we could" guard against it.

He said that as President he could not base policy on Soviet intentions but had to base it on Soviet capabilities.

In 1962 at the time of the Cuban missile crisis, he said, United States nuclear superiority was four or five to one over the Soviets, but now the gap has been closed.

Since 1967, when President Johnson approved the Sentinel ABM, intelligence estimates have revised upwards by 60 percent Soviet nuclear-missile and nuclear-submarine strength, Mr. Nixon said. He promised to fight "as hard as I can" for the limited ABM he proposed as a substitute for the Johnson system.

But he said that the nuclear superiority the United States formerly held would never be regained.

"We shall never have it again because it will not be necessary for us," the President said. "Sufficiency, as I have indicated, is all that is necessary."

NATIONAL SCIENCE FOUNDATION,
NATIONAL SCIENCE BOARD,
Washington, D.C., April 21, 1969.

The statement below is issued by the National Science Board with respect to recent events in connection with the appointment of a successor to Dr. Leland J. Haworth as Director, National Science Foundation. The statement was unanimously approved by the twenty-two Members of the Board who could be reached; the two Board Members who are Government officials were asked to disqualify themselves in this regard and are not party to this statement.

STATEMENT

The National Science Foundation is the Federal agency uniquely charged with assuring the strength of American science in the national interest. From the legislative history of the Foundation, the language of the National Science Foundation Act, and the record of almost two decades of dedicated service, it is abundantly evident that this agency has been viewed as a special national instrument whose programs and administration should be sheltered from the winds of political change.

The Board deeply regrets the recent break with this established tradition and essential practice when political concern was made paramount in the consideration of an eminently qualified candidate for the position of Director of the National Science Foundation. The Board will do all it can to minimize the resulting damage to internal morale and to the standing of the National Science Foundation in the community.

The Board will continue in its statutory task of advising the White House with respect to qualified candidates for this position. These recommendations will, as in the past, be based on the scientific and administrative competence and experience of the proposed candidates, the criteria which should be governing in the appointment of the Director of the National Science Foundation.

PHILIP HANDLER, *Chairman.*

[From the New York Times, Apr. 22, 1969]

SCIENCE FOUNDATION BOARD INDICATES NIXON DECISION ON DIRECTOR HURT MORALE AND LESSENED PRESTIGE

By Harold M. Schmeck, Jr.

WASHINGTON, April 21.—The chief policy-making body of the National Science Foundation issued a statement today expressing deep concern over President Nixon's decision to block the appointment of a new director for the foundation.

In its sharply worded statement, the National Science Board called the President's move a break with "established tradition and essential practice" and implied that the decision had damaged morale in the foundation and diminished its standing in the nation.

Last week Mr. Nixon decided against the appointment of Dr. Franklin A. Long, vice president for research and advanced studies at Cornell University, largely because of his opposition to the antiballistic missile system.

Mr. Nixon conceded this at his news conference Friday. While praising Dr. Long's credentials for the directorship, he said his appointment might have been misunderstood because of his difference of opinion with the Administraton on antiballistic missile defenses.

The foundation is a Government agency that plays a major role in support of basic scientific research throughout the nation. It has an annual budget of $500-million, most of which is spent in financing research at universities. Although an arm of the Government, it has always been considered nonpolitical.

The National Science Board, the foundation's policy-making body, consists of the director and 24 persons appointed to six-year terms by the President. All of its present members were appointed or reappointed during the Johnson Administration. They are prominent figures in science, education or business. The chair-

man of the board is Dr. Philip Handler of Duke University, president-elect of the National Academy of Sciences.

The statement said:

"The National Science Foundation is the Federal agency uniquely charged with assuring the strength of American science in the national interest. From the legisltaive history of the foundation, the language of the National Science Foundation Act, and the record of almost two decades of dedicated service, it is abundantly evident whose programs and administration should be sheltered from the winds of political change.

BOARD MEMBERS

In addition to Dr. Handler, Mr. Hardin, Dr. Haworth and Dr. Spilhaus, the members of the board are:

Dr. E. R. Piore (vice chairman, National Science Board), vice president and chief scientist, International Business Machines Corporation, Armonk, N.Y.

Dr. R. H. Bing, Rudolph E. Langer professor of mathematics, University of Wisconsin, Madison, Wis.

Dr. Harvey Brooks, Gordon McKay professor of applies physics and dean of engineering and applied physics, Harvard University.

Dr. Mary I. Hunting, president, Radcliffe College, Cambridge, Mass.

Dr. H. E. Carter, vice chancellor for academic affairs, University of Illinois, Urbana, Ill.

Dr. William A. Fowler, professor of physics, California Institute of Technology, Pasadena.

Dr. Julian R. Goldsmith, associate dean, division of physical sciences, University of Chicago.

Dr. Norman Hackerman, president, University of Texas at Austin.

Dr. William W. Hagerty, president, Drexel Institute of Technology, Philadelphia.

Dr. Roger W. Heyns, chancellor, University of California at Berkeley.

Dr. Charles F. Jones, president, Humble Oil & Refining Company, Houston.

Dr. Thomas F. Jones, Jr., president, University of South Carolina, Columbia.

Dr. James G. March, dean, School of Social Sciences, University of California at Irvine.

Dr. Robert S. Morison, professor of biology and director, division of biological sciences, Cornell University, Ithaca.

Dr. Grover E. Murray, president, Texas Technological College, Lubbock.

Mr. Harvey Picker, chairman of the board, Picker Corporation, White Plains, N.Y.

Dr. Mina S. Rees, provost of the graduate division, City University of New York, New York City.

Dr. Joseph M. Reynolds, Boyd professor of physics and vice president for instruction and research, Louisiana State University, Baton Rouge.

Dr. Frederick E. Smith, chairman, department of wildlife and fisheries, School of Natural Resources, University of Michigan, Ann Arbor.

Mr. Richard H. Sullivan, president, Association of American Colleges, Washington.

Dr. F. P. Thieme, vice president, University of Washington, Seattle.

[NOTE.—Reference should be made to the statement of the National Science Board, which is printed just before the above article.]

[From the Washington Post, Apr. 22, 1969]

SCIENCE BOARD DECRIES JOB VETO FOR ABM FOE

President Nixon's refusal to name Dr. Franklin Long of Cornell University as director of the National Science Foundation because of his opposition to the anti-ballistic missile was strongly decried yesterday by the National Science Board, which oversees that agency.

The presidentially appointed board called the action a break with the NSF's nonpolitical tradition, and one that will damage both its internal morale and its external standing.

Dr. Philip Handler—Duke biochemist slated to head the National Academy of Sciences starting July 1—is board chairman. Executive committee members include Dr. E. R. Piore, vice president of IBM; Dean Harvey Brooks of Harvard; and Dr. Robert Morison, Cornell biology chief.

[From the New York Times, Apr. 23, 1969]

Politics in Science

President Nixon's decision not to appoint Dr. Franklin Long of Cornell as director of the National Science Foundation because of his opposition to the anti-ballistic missle system has damaged the moral and prestige of an institution that should be totally divorced from politics. The 25-member National Science Board, the N.S.F.'s chief policy-making body, undoubtedly spoke for the bulk of the scientific and educational community in denouncing this break with "established tradition and essential practice."

There is a vital national interest in sheltering from political pressures the agency that channels $500 million a year of Federal funds into basic research and higher education for science. Mr. Nixon's decision will complicate the task of persuading another eminently qualified scientist to take the directorship. At the very least a strong White House pledge to keep politics out of science in the future is essential if irremediable harm is to be avoided.

The irony, of course, is that the rejection of Dr. Long has injured the chances for Congressional approval of the Safeguard ABM system far more than his appointment ever would have done.

[Note.—Reference should be made to the statement of the National Science Board, which is printed previously in this hearing record.]

[From Science Magazine, News and Comment, Apr. 25, 1969]

NSF Directorship: Why Did Nixon Veto Franklin A. Long?

The delicate web of understandings between scientists and the government seemed to be ripping apart last week. The precipitating cause for the sharp drop of scientific confidence in government was the revelation that the White House had, at the last possible minute, vetoed on political grounds Franklin A. Long's appointment as director of the nonpolitical National Science Foundation.

Nixon's rejection of Long, which was first publicly revealed by *Science* (18 April, p. 283), provoked a storm of protest among scientists and among congressional leaders, such as Senator Edward M. Kennedy and Representative Emilio Q. Daddario, whose support is crucial to NSF and to other science agencies. And, in a somewhat audacious act for a govermental body, the prestigious National Science Board criticized the vetoing of Long in a 21 April statement. The Board stated that it "deeply regrets" the administration's break with past practice of keeping the NSF and the choice of its director out of politics.

Despite a week of Presidential crisis over Korea and Vietnam, the Long furor received enough national press attention so that President Nixon was asked to explain his action at his 18 April news conference. Nixon replied:

. . . "The determination was made by members of the White House staff that his (Long's) appointment, in view of his very sincere beliefs opposing the ABM, would not be in the best interests of the overall Administration position. . . . (to) have at this time made an appointment of a man who quite honestly and quite sincerely—a man of eminent credentials, incidentally—disagreed with the Administration's position on a major matter of this sort—we thought this would be misunderstood. My staff thought that, and under the circumstances I approved their decision not to submit the recommendation to me."

Though the President shouldered responsibility for the decision and said it was based on disagreement with Long's ABM views, the more *Science* has looked looked into why Long was rejected, the more apparent it has seemed that other factors were involved. Full details of the Byzantine maneuvering that led to the blocking of Long's appointment will probably never be known, but opposition from the Republican side of Congress seems to have been a major factor in persuading the White House that the Long appointment should be dropped. Both Everett M. Dirksen, the Senate Republican leader, and Representative James G. Fulton, the senior Republican on the House Science and Astronautics Committee, which has authorizing responsibility for NSF, told *Science* they opposed the appointment.

Dirksen said that, when the White House asked him what he thought about appointing Long, he replied that he "didn't think it was a good idea." He said he had no "personal hostility" toward Long and was not worried about any effect the Long appointment might have on the upcoming Senate ABM voting,

but merely felt that "a person with his viewpoints, especially on the ABM, certainly didn't fit into the team."

Fulton meanwhile, claimed major credit for blocking the appointment. "I stopped it," he said. "I take the responsibility." When asked why he opposed Long, Fulton's initial response was, "I have my own type of candidate and it is not Franklin A. Long." Fulton's candidate is the president of a large eastern university, which happens to be Fulton's undergraduate alma mater. Fulton said that he stopped the Long appointment by organizing opposition "at three different levels in the White House, one of which is very close to President Nixon."

Talks with White House staff members give further credence to the idea that congressional opposition played an important part in stopping Long's appointment. One White House aide said that he had never heard of Long's appointment until a Republican on the House Science and Astronautics Committee approached him during the week of 6 April and complained about the choice of Long rather than the congressman's "candidate." The chief White House aide who handles congressional clearance of Nixon's nominees, Harry Fleming, said that he found opposition to Long "everywhere" in Congress. (Fleming declined to name members who were opposed.) It was Fleming's office which originally informed Fulton that Long was slated for appointment. After being asked if Fulton was correct when he claimed credit for stopping Long, Fleming replied that "the strong personal opposition of the ranking Republican on a crucial committee has to be very seriously considered. After all, they control the purse strings."

DISCOURAGING TALENT HUNT

The congressional opposition to Long seems to have been a cruel final blow administered in the late stages of a dishearteningly difficult and lengthy search for a new NSF director. *Science* has pieced together the outlines of the story by interviewing knowledgeable sources in the scientific community, the administration, and the Congress.

The tale starts with the National Science Board, the policy-making body for NSF, which has the statutory responsibility to nominate candidates for the NSF directorship. The term of the present NSF director, Leland J. Haworth, expires on 30 June, and while Haworth has not publicly evinced any particular desire to retire, the Nixon administration, even before taking office, made known its intention to appoint a new director to head the nation's basic research agency. Thus it was up to the Science Board to come up with some recommendations, and the board complied, suggesting two candidates—Emanual R. Piore, vice-president of International Business Machines Corporation, and H. Guyford Stever, president of Carnegie-Mellon University, who had served as chairman of Nixon's advisory task force on science. Both men had told the Science Board they would seriously consider the NSF job if it were offered, but after formal negotiations with Lee A. DuBridge, Nixon's science adviser, both decided to withdraw their names from consideration.

The ball was then tossed back to the Science Board, which was asked to come up with some more names. The Science Board nominated two more men, one of whom was Franklin Long, of Cornell. (The identity of the other man and the status of his candidacy are not known at this writing.)

Long in many ways seemed an ideal choice. He had had extensive Washington experience on the President's Science Advisory Committee (1961–66), as the first assistant director for science and technology in the U.S. Arms Control and Disarmament Agency (1962–63), and as an adviser to various military agencies. He was an eminent physical chemist and member of the prestigious National Academy of Sciences. He had administrative experience as vice-president for research and advanced studies at Cornell. Moreover, he was available, for he was about to resign as vice-president at Cornell to return to teaching.

DU BRIDGE BACKED LONG

By all accounts, Long was endorsed for the NSF directorship by science adviser DuBridge. Long was first approached about the NSF directorship in late February. After a number of discussions with DuBridge, he decided the opportunity at NSF looked promising, and he agreed to take the job. Subsequently, according to knowledgeable sources, Long was actually told by DuBridge that the appointment was all set.

At one point, plans were made for Long to meet with the President, and for an announcement of his appointment to be made, but the plans had to be postponed

because of President Nixon's involvement in the funeral of the late President Eisenhower. Then a new date was set—Friday, 11 April. Long was tentatively scheduled to meet with the President at about 3 p.m. to conclude formal discussions, and a public announcement was to have been made shortly afterward, probably at the Friday afternoon press briefing for White House reporters.

As late as Friday morning everything still seemed in order. The appointment had been approved by members of the congressional delegation from New York, Long's home state; both NSF and Cornell had biographies of Long ready to release to the press at the time of the announcement; and Long left for Washington still believing he would meet with the President to conclude formal negotiations. But when Long arrived in Washington he found, according to a statement he later released to the press, that "the situation had changed and that new elements of a political nature relating to the antiballistic missile system had arisen." Both the meeting with the President and the formal announcement were canceled. Long met with DuBridge, but not with Nixon.

WHITE HOUSE FEARS

Neither Long nor DuBridge will discuss details of what transpired at their meeting, but knowledgeable sources say DuBridge revealed that the stumbling block was Long's opposition to the ABM. These sources say Du Bridge told Long that political advisers in the White House were apprehensive that appointment of an ABM opponent to a high federal post might jeopardize the administration's efforts to win congressional approval of the ABM. The White House is said to have feared that Long's appointment might be misconstrued as evidence that the Nixon administration was not firm in its desire to win approval of the ABM. There were also fears that ABM opponents in the Senate might use confirmation hearings on Long's appointment to embarrass the administration by focusing attention on the fact that Nixon's own Science Foundaion director opposed the ABM. The hearings would be held by the Senate Labor and Public Welfare Committee, which includes Senator Edward M. Kennedy (D-Mass.), a leading ABM opponent and a leading contender for Nixon's job. Kennedy is the chairman of the Senate subcommittee which oversees NSF and helps determine NSF's budget authorization.

DuBridge has continually refused to discuss Long's rejection with *Science*, both before and since the story was published. However, in his only public statement on the matter—made to the New York *Times*—DuBridge implied that Long understood the administration's political problem and therefore voluntarily withdrew. "He could see, and was informed of the critical political situation on the hill," DuBridge is quoted as saying. "So by mutual consent we terminated our discussions of the post." This seems to be considerably less than a full explanation of what happened.

ALTERNATIVES OFFERED

According to knowledgeable sources, DuBridge told Long he could have the NSF post if he agreed to support the President's proposed Safeguard ABM system, or if he agreed to have his appointment held up until after the crucial voting on the ABM in Congress. Alternatively, DuBridge asked Long to withdraw his name from consideration and to devise a suitable "personal reason" for doing so. Long is said to have found the three alternatives "totally unacceptable," so the discussions were terminated. DuBridge is said to have told Long he was "really sick" about the whole incident.

Ironically, Long has never taken a public stand on Nixon's Safeguard system, and he is said to have scrupulously avoided making any public statements on the matter because he expected to become NSF director and didn't want to involve the agency in political controversy—a vain hope as it turned out. Long has, however, previously gone on record as opposing the ABM concept, most recently in an article in the December 1968 issue of the *Bulletin of the Atomic Scientists*, which was published before Nixon came out with his revised ABM plan. Sources close to Long insist that Long's ABM views, and his long-standing liberal record on arms-control matters, were well known to the Nixon administration and had, in fact, been discussed between Long and DuBridge well before the fiasco of 11 April.

Although Congressman Fulton probably hit hard at Long's ABM views when talking to the White House staff members and may well have alerted some key political staff members to Long's reservations in the matter, it is clear that Fulton is not primarily motivated by opposition to Long's position on the ABM.

Indeed, Fulton opposes deployment of the ABM. What Fulton emphasizes is that Long is not "my type of candidate." Fulton's candidate is Eric A. Walker, 59, former chairman of the National Science Board, president of the National Academy of Engineering, and president of Pennsylvania State University for the past 13 years. Walker has told the Penn State trustees that he wants to resign by June 1970. Fulton said he had not talked to Walker about the NSF directorship.

In a telephone interview with *Science*, Walker said he didn't realize he was Fulton's candidate for the NSF directorship, and continued, "I know Jim, but I haven't talked to him for three months." Walker said his last conversation with Fulton concerned NASA. Walker's own comment on the blocking of the Long appointment was: "My feeling is that people are hollering before they know the facts. If a man has taken a public stand on something it can be a handicap to being a good administrator of NSF. Sometimes it's good to have a faceless man in that kind of position."

FULTON'S OTHER OBJECTIONS

In addition to having his own type of candidate, Representative Fulton mentioned other reasons for opposing Long. He said that his opposition had nothing to do with the fact that Long is a Democrat: "Of course it isn't politics; it concerns the direction I want NSF to go." Fulton said that he wanted NSF to be an agency supporting the natural sciences exclusively, and that he did not want NSF to get mixed up in controversial matters like social science support or "integration of the schools." When asked, Fulton did not explain why he thought Long would change the direction of NSF in these ways, except that Long is, in Fulton's opinion, a "controversial figure." Fulton said, "I don't want these controversies brought into the NSF." On several occasions, Fulton asserted, Long was a "fence-sitter" or a "fence-straddler." As support for his allegation, Fulton said that, first, Long had served as a consultant to the Army and as a member of the Air Force Scientific Advisory Board from 1956 to 1963, "where he supported the ballistic missile"; second, that Long was now opposed to developing a ballistic-missile defense; and third, that Long had served as an assistant director of the Arms Control and Disarmament Agency. In Fulton's opinion, serving in these three different capacities was intellectually contradictory, represented "a checker-board of thinking," and reminded him of "Alice in Wonderland."

When Fleming's office called Fulton during the week of 6 April, the congressman gave an immediate "no." "And when I say no, it's no," Fulton said. Fulton explained that he was close to Nixon, being a co-chairman for Nixon in Pennsylvania during the campaign, one of the first seven congressmen to support Nixon, and one of a small group of congressmen to receive a silver medal from Nixon for his services.

JAVITS' ROLE

When Fulton learned of the plan to appoint Long, he said he contacted Senator Jacob K. Javits, the senior Senator from Long's home state of New York. When he contacted him, Fulton said, Javits had not even been informed of the intention to appoint Long. "Javits backed us up" in opposing Long, Fulton said, and explained that he and Javits were longtime friends. Although Javits would not speak to *Science* about the Long veto, a spokesman for Javits was authorized to say that, although Fulton called Javits about Long, Javits never did take a firm position, either for or against Long's appointment.

Although Javits' position on this appointment may have helped Fulton in his effort to stop Long, some of the other Republican legislators consulted on the appointment approved Long. Republican Charles E. Goodell, New York's junior Senator, told *Science* that he had been consulted by the White House in advance, had supported Long's appointment, and would try to reverse the White House decision. Howard W. Robison, chairman of the House Republican delegation from New York and the representative from the district in which Long lives, told *Science*, "I approved and endorsed Long instantly and most enthusiastically." After the Long veto was revealed in the press, on 17 April, Robison wrote a letter of protest to the White House and asked that the veto be rescinded. "The whole thing is regrettable; an error of judgment has been made," Robison said, adding that the veto of Long would not only be unpopular in academic circles but would be "hurtful to gathering support for the ABM in Congress." As have several other sources, Robison singled out White House aide Bryce Harlow as one of those who advised Nixon that it would be a mistake "on political grounds" to appoint Long.

Very few congressmen seems to have been consulted in advance on the Long appointment. *Science* was not able to find the evidence to support Harry Fleming's contention that he found congressional opposition to Long "everywhere." Democrats seem not to have been consulted at all. Not even key Republicans like Charles A. Mosher (Ohio), second-ranking Republican on the House Science and Astronautics Committee, and Senator Winston Prouty (Vermont), senior Republican on the NSF and education subcommittees, seem to have been consulted about Long.

KENNEDY STATEMENT

The veto of Long aroused the wrath of key Democratic legislators in the chambers of Congress. Senator Kennedy, who is chairman of the authorizing subcommittee for the National Science Foundation, took the Senate floor on 18 April and said: "I share the distress of the scientific community, as outlined in the 18 April issue of *Science* magazine, that the administration appeared to have chosen an outstanding leader of the scientific community, Dr. Franklin A. Long, to serve as the next director of NSF, and then had reversed its decision. The NSF is engaged solely in civilian, nonmilitary research; it will benefit no one if the apolitical status of the NSF is changed."

Daddario, the chairman of the House subcommittee which handles the NSF authorization, was even more critical and accused the Nixon administration of "sacrificing the National Science Foundation on the altar of the ABM." He said it is "absurd" to involve the NSF directorship in the ABM issue and wondered if NSF should be henceforth considered part of the Defense Establishment.

The Long affair provoked quick cries of indignation from the scientific community. The governing board of the Federation of American Societies for Experimental Biology (FASEB), the nation's largest biology group, charged, in a formal resolution, that the rejection of Long was "both unfortunate and in error and potentially serious in its longterm effects on American science." The federation happened to be holding its annual meeting in Atlantic City and was able to respond immediately to the news of Nixon's rejection of Long.

Eminent individual scientists have also deplored the Nixon administration's action. All four previous science advisers, in response to queries from *Science*, said they were upset over the implications of the Long incident.

James R. Killian, Jr., science adviser to the late President Eisenhower, called the rejection of Long "troubling" and said it is "urgently important" for the Nixon administration to reaffirm the nonpolitical nature of the NSF directorship so that the foundation can "command the confidence it must have."

George B. Kistiakowsky, Killian's successor as science adviser to Eisenhower, said he was "gravely distressed and troubled about the mixing of military issues into the process of appointing the director of an agency that has nothing to do with military policies."

Jerome B. Wiesner, science adviser to the late President Kennedy, said he is "very troubled" at the "politicalization" of the science foundation and at the notion that the Nixon administration "will systematically exclude" opinions it doesn't like, with the result that "people with contrary scientific opinions will be very reluctant event to talk about a post in the Administration."

And Donald F. Hornig, science adviser to former President Johnson, said he is "deeply distressed" at Long's rejection because Long is a "first-class man'" and because he (Hornig) wouldn't like NSF to become a political agency.

Another prominent member of the science establishment, Robert L. Sproull, chairman of the Defense Science Board, said he is extremely disappointed" because he expected Long to be a "very strong and imaginative director" of NSF.

H. Guyford Stever, one of the two nominees who turned down the NSF directorship before Long was approached, commented that he didn't think that partisan views should be considered in choosing the NSF director but added: "No administration can withstand within itself an activist against itself."

The President is not required to appoint a scientist as NSF director, and he is under no obligation to pick a candidate nominated by the National Science Board. But DuBridge told *Science* he would not support a candidate who had not been recommended by the board, and DuBridge, in fact, has already asked the board to come up with more names. The board, in its recent statement criticizing the President's action, said it will continue to advise on qualified candidates and that its advice "will, as in the past, be based on the scientific and administrative competence and experience of the proposed candidates, the criteria which should be governing in the appointment of a director of the National Science Foundation." The politely worded rebuke to the President was approved by all of the 21

board members who could be reached. The statement was released over the signature of Philip Handler, board chairman, who was one of the first prominent scientists to express opposition to the Administration's action. The two board members who are government officials—Clifford M. Hardin, secretary of agriculture, and Haworth—were not asked to support the statement.

The Long incident seems to be one of those sorry affairs where there are many more losers than winners. In fact, there may be no winners at all, except possibly Dirksen and Fulton.

The NSF, which has been staggering under the burdens of a tight budget and a lame-duck director, is clearly a big loser, for it faces serious morale problems and an even more uncertain future. Almost everyone concerned predicts that it will be exceedingly difficult to find a new NSF director, partly because scientists may be unwilling to do anything that might be interpreted as a slap at Long, partly because few scientists will want their colleagues to think they got the job by submitting to—and passing—a political Wassermann test.

DuBridge, who had made such a promising start as science adviser (*Science*, 21 February), has also suffered unfortuate losses. His key role in an incident that embarassed the administration may have shaken his standing at the White House. And the fact that he was obviously overruled by White House political advisers has hardy enhanced his stature in the eyes of the scientific community.

I. I. Rabi, Nobel prize-winning physicist and a personal friend of the late General Eisenhower, wonders if DuBridge "now has a tin can tied to his tail—is he serving as 'yes man' or can he express himself?" And former science adviser Hornig believes the incident is "undoubtedly going to complicate the role of the President's science adviser," and makes it "very difficult" for DuBridge.

Nixon also appears to be a big loser. It remains to be seen whether the veto of Long will bolster the Administration's fight for the ABM, as Nixon apparently hoped, or will actually weaken the Administration's hand by focusing attention on the opposition and by indicating that the Administration thinks its congressional support on the ABM issue is shaky.

But there is little doubt that the Long veto will undermine the professed efforts of Nixon and DuBridge to "heal the breaches" between the government and the scientific community which have developed over the Vietnam war, the ABM, and various military issues. The incident will make it more difficult for the White House to attract scientific talent, and it raises questions about Nixon's seriousness in professing his desire to be exposed to all points of view.

As far as *Science* can determine, these are the major elements of the rejection of Franklin A. Long as director of the National Science Foundation. Although Long's views on ABM seem to have been an important cause of his rejection, these views may well have been made visable as a result of some rather mundane politicking by Republican congressmen. If the consequences of this politicking had not been so profound, this whole episode would make a bizarre and engrossing story. Because it has been so drastic in its results, we can only conclude that the rejection of Franklin A. Long, and the manner by which that vetoing was accomplished, marks one of the most disruptive episodes in a usually harmonious relationship between the federal government and the scientists.

The long-time alliance between science and the federal government, is to say the least, strained. The alliance has been, for the most part, a smoothly working gentlemen's agreement during the past quarter century. In return for their cooperation with the government and for the reticence of scientific leaders on many political questions, scientists have received federal funds and a large measure of influence in determining who will direct the federal scientific effort and how the funds will be distributed.

NSF has a strong symbolic significance to the scientific community. Probably without realizing the implications of what it was doing, the White House has severely shaken scientific confidence that the relationship will continue as it has in the past. In contrast to his stated intentions, President Nixon has widened the breach between the federal government and the scientific community. For the good of all parties, it can be legitmately hoped that the President will try to bridge the gap that has been created by his politically motivated rejection of Franklin A. Long.—*Philip M. Boffey and Bryce Nelson.*

[From the Washington Post, Apr. 25, 1969]

Representative Fulton Tells of Role in Long Veto

(By Victor Cohn)

Rep. James G. Fulton (R–Pa.) identified himself yesterday as the one who prompted President Nixon to veto Dr. Franklin Long of Cornell University as director of the National Science Foundation.

"I was first to oppose him," Fulton said.

Later Senate Republican leader Everett M. Dirksen also opposed Long and claimed some credit for blocking his appointment.

The President said last week he vetoed Long because the appointment might be "misunderstood" in view of Long's opposition to antiballistic missiles. But Fulton—ranking Republican on the House Science and Astronautic Committee, which oversees NSF funds—gave other reasons.

"I have said I will not vote for the ABM," Fulton said, "so it wasn't that. It was because, one, Long is a man of controversy and I want to keep the NSF in a scientific atmosphere and not one of controversy.

"This is an issue now because Daddario"—Rep. Emilio Daddario (D–Conn.), Science Subcommittee head—"feels NSF should move into social science. I'm co-sponsor of the National Foundation on the Arts and Humanities, but I believe NSF should stay out of this sticky wicket and controversies like integration and civil rights. It would just cut down the money for natural sciences.

"And, two, Long has been on all sides of various questions. What are his principles?"

Fulton based this anti-Long analysis, he said, on the fact that Long first "worked for the Army and Air Force on missiles, then was assistant director (for science and technology) of the Arms Control and Disarmament Agency, and now is against the ABM, and this certainly doesn't show any cohesion or logic."

Long, research vice president at Cornell, declined comment. The record shows only that Long—like practically all the other prominent scientists who have opposed the ABM—was indeed for a long while a weapons consultant.

He worked at the Alleghany Ballistics Laboratory in World War II. In the 1950s he was consultant to the Aberdeen Ballistics Laboratory, then on the Air Force Scientific Advisory Board.

In the late 1950s he chaired a strategic weapons panel of the President's Science Advisory Committee.

He served in ACDA in 1962–63, has worked for arms control since and in December wrote an article arguing against antiballistic missile deployment as a bar to disarmament negotiation. But he has taken no specific stand on the Sentinel or Safeguard systems.

Mr. Nixon's action has triggered wide protest by scientists, and Fulton's explanations are likely to add to it. Science—weekly journal of the American Association for the Advancement of Science—will say in a news report today that NSF now faces "serious morale problems"—and that Presidential Science Adviser Lee A. DuBridge may now have lost standing both with the President and scientists.

Science said White House aides Bryce Harlow and Harry Fleming were prominent in the decision to veto Long.

Fulton said his candidate now for NSF head is Dr. Eric A. Walker, president of both the National Academy of Engineering and Pennsylvania State University. Walker has been absent from candidate lists submitted by the National Science Board, presidentially-appointed body which directs the NSF, and DuBridge so far has relied on this board's suggestions.

[From the Congressional Record, Apr. 29, 1969]

President Nixon's Reconsideration of Dr. Long to be Director of National Science Foundation

Mr. Mansfield. Mr. President, President Nixon's personal reconsideration of Dr. Franklin Long, of Cornell University, to be the Director of the National Science Foundation is commendable. I was not shocked at the earlier decision regarding the directorship of the National Science Foundation. That is not to say, however, that I was not concerned. I am impressed now by the fact that the

President conceded that he had been wrong not to appoint Dr. Long earlier because of the latter's alleged opposition to the ABM.

It is my understanding that the President, through intermediaries, asked Dr. Long last week whether he would care to have his name submitted for the post of Director of the National Science Foundation. Dr. Long evidently refused because he felt that he did not wish to see the matter reopened which, of course, was his right.

The significant point in this situation is that the President of the United States was prepared to acknowledge an error. Such an admission on the part of the President can, at times, serve as a tonic for what is most human and reasonable in the Nation. The admission helps to clear the decks and promises a great deal in the way of better understanding in the future.

Mr. President, if I may become personal, I knew nothing of the possibility of Dr. Long being considered for the directorship of the National Science Foundation. However, I have known Dr. Long and his family for a good many years. He was born in Great Falls, Mont. He was raised in Eureka in Lincoln County in the northwestern part of the State. In my opinion he is one of the most outstanding scientists on the American scene today.

I again commend the President for what he has done and I think it makes him a bigger man, as well.

Mr. Scott. Mr. President, will the Senator yield?

Mr. Mansfield. I yield.

Mr. Scott. Mr. President, with reference to the very fine statement which has just been made by the distinguished Senator from Montana, may I observe that to err is human and to forgive is democratic.

[From the New York Times, Apr. 29, 1969]

NIXON ADMITS ERROR ON SCIENCE NOMINEE

(By Robert B. Semple, Jr.)

Washington, April 28.—President Nixon conceded today that he had been wrong to deny a prominent Cornell scientist the directorship of the National Science Foundation because of the scientist's opposition to the proposed antiballistic missile system.

The President made his admission of error at a White House meeting this afternoon with a group of prominent scientists from the National Academy of Sciences and the National Science Foundation.

Mr. Nixon's views and comments were transmitted to newsmen later by his press secretary, Ronald L. Ziegler, and by his science adviser, Dr. Lee A. DuBridge.

Mr. Nixon told the board members that, through intermediaries, he had asked the scientist, Dr. Franklin A. Long, last week whether he would care to have his name resubmitted for the post.

Dr. Long reportedly refused because he did not wish to see the controversial case "reopened."

The President also told his guests that he shared their views about the nonpolitical character of the National Science Foundation post and agreed that all candidates should be judged only on the basis of their scientific and administrative qualifications.

NEW NAMES SOLICITED

According to Mr. Ziegler, who attended the meeting, the President, after expressing his changed views on the Long episode, asked the board members who were present to submit names of qualified candidates to the White House.

He then told them, Mr. Ziegler reported, that "based upon their recommendations he would nominate an individual without regard to any factor other than his qualifications for the post."

A candidate's views on the antiballistic missile system, Mr. Ziegler emphasized, would not be a factor "in the choosing of this man."

Mr. Nixon's statement to the scientists represented a rare public mea culpa (admission of error) by a President as well as a complete reversal of his earlier position on Dr. Long.

Dr. Long had been proposed for the post by the National Science Board and had received a strong recommendation as well from Dr. DuBridge.

About six weeks ago, Dr. DuBridge approached Dr. Long about the job. After several discussions, Dr. Long decided to accept. He came to Washington on April 11 under the impression that he was to meet the President in the afternoon and that an announcement of his appointment would be made shortly thereafter.

REBUFF TO DR. LONG

When he arrived, however, he was told that some members of the President's staff—who have remained unidentified—were opposed to the appointment. They had canvassed sentiment on Capitol Hill, he was told, and had concluded that Dr. Long's opposition to the ABM might jeopardize his confirmation.

The Senate opposition would place the Administration in the awkward position of promoting a man opposed to the ABM system at the same time that it was lobbying for the system itself.

At his news conference April 18, in response to a question, Mr. Nixon said that Dr. Long's name had never reached his desk for final approval but that he "approved of their [his staff's] decision not to submit the recommendation to me."

Dr. DuBridge said today that shortly after the April 18 news conference he had gone to the President and talked the entire matter through.

He said he had told the President that the Long episode had been unfortunate and had caused serious repercussions in the scientific community, which was otherwise favorably disposed toward Mr. Nixon because of his decision earlier this year to restore some funds to the National Science Foundation.

He argued further that the question of Dr. Long's appointment had received inadequate staff consideration in the White House and, in any case, should not have been made a matter of partisan politics.

Dr. DuBridge emphasized the fact that even though the foundation was Federally supported—at a ratio approaching $500-million annually—scientists themselves regard it as a nonpolitical group. Mr. Nixon, his adviser said, agreed with this thesis.

Asked what reaction he expected from the scientific community to Mr. Nixon's shift in stance, Dr. DuBridge replied:

"I'm sure it will be tremendously pleased and encouraged."

Dr. DuBridge and Mr. Ziegler conceded that today's meeting had been called in part to help mend Mr. Nixon's frayed relationships with the scientific community, which had almost unanimously condemned his earlier action.

But they stressed that a wide range of issues had been touched on and that the President had assured his guests of his continuing interest in scientific research at home and scientific cooperation abroad.

Mr. Ziegler and Dr. DuBridge reported that the case of Dr. John H. Knowles had also come up in the discussion. Dr. Knowles is under consideration for the post of Assistant Secretary of Health, Education and Welfare for Health and Scientific Affairs. He is being strenuously opposed by the American Medical Association and the Senate minority leader, Everett McKinley Dirksen, who has also claimed some credit for blocking the Long appointment.

Mr. Nixon was reported to have told the scientists that Dr. Knowles was still "under consideration" and to have solicited their views on his appointment.

[From the Science World, Apr. 28, 1969]

Franklin Long Rejection Shocks Scientists

Disbelief and shock reverberated through the scientific community following President Nixon's rejection on political grounds of Franklin A Long as the next director of the National Science Foundation. Long, 58, is vice president for research and advanced studies at Cornell. He had accepted the NSF post informally, but over the weekend of April 12–13 his opposition to the ABM proposal came back to haunt him. Washington observers believe that Sen. Everett Dirksen recommended that Long be rejected, and Nixon agreed.

Reaction was swift. "I find it a little shocking because all of us think of the NSF directorship as a nonpolitical post," said Donald Hornig, science adviser to former President Johnson. "What bothers me is that if this is the way that scientific people are to be regarded, I think one is going to find it much harder to get good people to come to government positions."

The National Science Board said it deeply regretted the break with the tradition of keeping the NSF directorship nonpolitical, declaring: "The Board will

do all it can to minimize the resulting damage to internal morale and to the standing of the NSF in the community."

Said Columbia's I. I. Rabi: "I am deeply shocked. It is unprecedented. It gives this Administration a very bad start. There will be a big reaction from the scientific community; they are very upset. Now, apparently, it is a prerequisite to be for something backed by the President to get the job. I don't know how far this will go."

[From the Washington Post, Apr. 29, 1969]

Nixon Vows To Fill NSF Job on Merit

(By Carroll Kilpatrick)

In a major policy reversal, President Nixon promised yesterday to nominate a director of the National Science Foundation without regard to his position on the Administration's anti-ballistic missile proposals.

At a meeting with members of the National Science Board and the council of the National Academy of Sciences, the President asked for names of a possible nominee and promised to consider only his scientific qualifications.

The President also disclosed that after his original decision not to nominate Franklin A. Long, vice president of Cornell University, for the post, he had asked Long to consider having his name submitted to the Senate. Long refused.

Lee A. DuBridge, the President's science adviser, who talked to Long, told newsmen that the Cornell scientist refused because he found "the political situation distasteful to him and he preferred not to have it reopened."

After the veto of Long because of his opposition to the ABM and because of opposition from well-placed Congressional Republicans, scientists and others vigorously attacked the President for his decision, which they said injected politics into science.

At his April 18 news conference, when asked about the reported objections to Long, Mr. Nixon said that the determination was made by the White House staff not to offer the job.

The President said he supported the staff's decision because he believed the nomination of a scientist strongly opposing the ABM "would be misunderstood."

Both Senate Minority Leader Everett M. Dirksen (R-Ill.) and Rep. James G. Fulton (R-Pa.), senior minority member of the House Science and Astronautics Committee, opposed Long and took credit for blocking his nomination.

After the President's meeting with the scientists yesterday, DuBridge said he originally urged Long's nomination. The White House staff blocked it, however, before he had an opportunity to argue the case fully with the President, he said.

After the news conference in which the President frankly acknowledged that Long's name would not be submitted, DuBridge went to the President because he felt it was a matter he should more thoroughly consider, DuBridge said.

The President then instructed hm to ask Long if he would permit his name to be reconsidered, DuBridge reported.

BOARD TO RECOMMEND

In reporting the President's promise to the scientists, Press Secretary Ronald L. Ziegler said that Mr. Nixon would nominate one of the men proposed by the National Science Board. He declined to discuss the Congressional opposition to Long or its implications for another nominee.

The President told the scientists he would support the independence of the NSF and assured them of his interest in science and in international scientific cooperation, Ziegler said.

Asked why the President changed his position on the NSF nomination, DuBridge said that Mr. Nixon "looked at it more carefully" and decided that only scientific qualifications should be considered.

At the meeting with the scientists, the President asked their opinion of Dr. John Knowles, a controversial figure under consideration for nomination as an Assistant, Secretary of Health, Education and Welfare.

Knowles, director of Massachusetts General Hospital, is the candidate of HEW Secretary Robert Finch for the top health job in the department.

But his nomination has been held up because of Republican Congressional opposition and opposition from elements of the American Medical Association.

Ziegler said Knowles' name "is still under consideration."

[From Science Magazine, May 2, 1969]

NSF Director: Nixon Admits He Was Wrong

Magnanimity in politics is not seldom the truest form of wisdom.—
EDMUND BURKE

In a remarkable reversal, President Nixon announced this week that the White House had been wrong in blocking the appointment of Franklin A. Long for political reasons as the new director of the National Science Foundation. In a 28 April meeting with members of the National Science Board and the Council of the National Academy of Sciences, Nixon said that the next NSF director would be chosen on the basis of scientific and administrative competence and would be chosen from names submitted by the National Science Board.

Not only did Nixon give dramatic affirmation to the view of the scientific community that the NSF directorship is a nonpolitical post, but he also took the unusual step last week of offering the NSF directorship to Long. Although Long said that he greatly appreciated the offer, he declined the job. Long told *Science*, "The earlier events had inescapably made me become a politically marked and polarized figure so that my presence would make both the operations of the NSF and the carrying out of its administration more difficult."

Nixon personally conveyed his change of mind to the scientific leaders at a half-hour meeting at the White House. The substance of his remarks was later transmitted to newsmen at a press briefing held by Presidential science adviser Lee A. DuBridge and press secretary Ronald L. Ziegler, and this official version was amplified for *Science* by participants in the meeting with the President.

After having told the scientists that Long had declined to take the NSF post because his name had become associated with political controversy, Nixon is reported by one scientist at the meeting to have made a statement about Long to the effect that "Now I respect him even more."

The Nixon reversal, in the opinion of National Academy of Sciences president Frederick Seitz, "cleared the air" of the thunderstorm of criticism that had developed over the rejection of Long because of his political views, especially his reservations about ABM deployment. Seitz, who, like the other scientists who attended the White House meeting, seemed happy about the change in Nixon's decision, observed, "The President wanted the scientific community to know that he regretted the situation and wanted to make amends." Another Academy member who attended the meeting said he was "flabbergasted that the President would say, in effect, 'I goofed' and would try to make amends."

In the scientific community's lengthy battle to establish federal research funding as a nonpolitical area, the reversal of the White House veto of Long is a highly significant victory. National Science Board chairman Philip Handler observes that the Long episode marks the first time the nonpolitical nature of the NSF directorship has been really tested and affirmed.

The White House meeting on 28 April also greatly pleased the scientists because Nixon emphasized the importance he placed on the NSF, on scientific research, and on science as a means of international cooperation. "He said all the rights things and he said them very well," one scientist exclaimed. DuBridge said the White House meeting also marked the first time since the Hoover Administration that the Council of the National Academy had met with a President. (The National Science Board had had an earlier meeting with Nixon on 13 February.)

At the meeting with the scientists and at the press briefing afterward, Nixon and DuBridge revealed a few more details concerning how the original rejection of Long occurred. The gist of their explanation was that White House political aides, upset by a last-minute negative reaction from Capitol Hill, bungled the Long appointment before the President was fully aware of what was happening. One scientist who attended the meeting with Nixon said Nixon acknowledged that the Long affair had been "very badly handled" by the White House.

Long had been nominated for the directorship many weeks ago by the National Science Board, the policy-making body for NSF, and DuBridge confirmed at Monday's press briefing the report that he had personally backed Long for the job. But when Long came to Washington on 11 April, expecting to meet with the President and conclude formal negotiations, he found that the arrangements were off. Subsequently, the President, on 18 April, told a news conference that he personally had approved a decision by White House aides not to submit Long's name to him because of Long's opposition to deployment of an antiballistic

missile system. The White House feared that appointment of Long might damage the Administration's efforts to win congressional approval for the ABM.

At the press briefing this past Monday, DuBridge told reporters that White House staff members, after finding opposition to Long on Capitol Hill, did not bring the matter of Long's appointment to the President for "careful consideration." DuBridge said that, although he meets with the President "on a regular basis," it proved "impossible to get all this settled" before Long's rejection became a *cause célèbre* and had to be dealt with at the President's televised news conference. DuBridge later told *Science* that he first learned of congressional objections to Long on 10 April, and that he was unable to get to Nixon to straighten out matters before Long's arrival in Washington on 11 April. Neither DuBridge nor Ziegler, Nixon's press spokesman, would identify the White House aides or the congressional figures involved in blocking Long's appointment. The only two congressmen whom *Science* could discover in opposition to Long were Senate Republican leader Everett M. Dirksen and Representative James G. Fulton (*Science*, 25 April, page 406). Although the new NSF director must be confirmed by the Senate, the Nixon Administration does not appear greatly worried about difficulties in obtaining Senate approval.

Ziegler told reporters that, while the President originally seemed to accept the political aides' premise that Long's name should not be presented to him for the NSF post because of the political situation, he changed his mind after conversations with DuBridge. DuBridge told reporters that the President, when he looked into the matter "more carefully," realized that the qualifications for the post should involve solely the scientific competence, administrative ability, and personal characeristics of a candidate. DuBridge and Ziegler made it clear that neither party politics nor ABM considerations would be considered relevant to the choice of a new NSF director.

The President told DuBridge that he was willing to have Long's name proposed to him, and both DuBridge and Henry Kissinger, Nixon's special assistant on national security affairs, who is a long-time friend of Long's, called Long to ask him to consider taking the post, but Long declined.

The President's unusual about-face seems to have been brought about partly by the storm of protest from the scientific community. Another major factor was the effort of DuBridge, who argued his case effectively and also developed an important high-level ally in Kissinger.

The news of Long's rejection for political reasons was first publicly revealed in the 18 April issue of *Science*. The story was immediately given frontpage coverage by the New York *Times* and other prominent newspapers. It provoked an overwhelmingly negative reaction from the scientific community. DuBridge told reporters that there had been considerable reaction in the scientific press, particularly *Science*, and in newspaper editorials. He also said there had been "many letters" of protest to Nixon and himself from individual scientists and various scientific bodies. Many prominent scientists with White House connections are also said to have called to register complaints. Among the organized groups which deplored the rejection of Long were the leadership of the National Academy of Sciences, the National Science Board, and the Federation of American Societies for Experimental Biology, the nation's largest biology group. A key role in working for a reversal of the Long decision was played by Philip Handler, chairman of the National Science Board, who managed to mobilize opposition by key scientific groups without, apparently, undercutting his ability to negotiate effectively with the White House.

While almost all those involved suffered from the original decision to block Long's appointment, the concerned parties seem to have gained in prestige from the reversal of the decision on Long. DuBridge, whose advice on a major scientific post had been originally rejected by White House political aides, now emerges as a man influential enough to help convince the President that he should change a publicly announced decision which allowed political factors to affect the appointment of an NSF director. DuBridge had originally given the impression of being close to President Nixon (*Science*, 21 February). This impression was somewhat dispelled by the rejection of Long, but DuBridge's reputation now seems enhanced by his role in securing the reversal of the decision.

The scientific community has displayed unusual effectiveness in achieving its goal in the Long incident. It has been successful in giving emphasis to its view that the NSF directorship is nonpolitical and has also proved itself powerful enough to persuade the President that he made a mistake.

It is difficult for Presidents to retract their decisions in public, but it is hard to see that Nixon has done anything but help himself in reversing the Long decision. He has offended very few people, and he seems to have gained a new respect in the scientific community. Furthermore, Nixon's reversal on Long may have enhanced his reputation among the larger public. At little, if any, political cost. Nixon has shown himself to be a man who is not too proud to admit error.—*Philip M. Boffey and Bryce Nelson.*

PREPARED STATEMENT OF DR. WARREN C. STOKER, CHAIRMAN, CONNECTICUT RESEARCH COMMISSION, STATE OF CONNECTICUT

The Connecticut Research Commission was established in July of 1965 to provide State funds in support of research in the interest of the citizens of the State. The Commission has invested a total of $2.6 million of State funds in support of research that holds promise of solving a problem or capitalizing an opportunity of significance to the State. A list of research projects supported through December 31, 1968 is appended to this testimony.

The Research Commission's program has verified that the State benefits from the investment of State funds in support of research. The Commission has proven to be an effective mechanism to identify problems and opportunities worthy of research and to encourage the State's research resources to conduct research in the areas so identified.

Most of the research projects supported by the Research Commission will have application beyond the geographic boundaries of Connecticut. Therefore, it would appear to be appropriate for a federal agency such as the National Science Foundation to provide matching funds in support of this research.

The Research Commission is aware of interest by the National Science Foundation to increase the potential for scientific activity in state and local government. The Commission understands that the Foundation has requested $150,000 in its Fiscal Year 1970 budget to support this interest. At its meeting on May 8, 1969, the Commission unanimously supported this effort.

However, the Commission feels that this level of support is insufficient to produce meaningful results. It recommends that a substantially larger sum be appropriated to the National Science Foundation for FY '70 in support of this activity. An increased appropriation would permit the National Science Foundation to provide matching support of pilot programs in several of the States to increase the potential for scientific activity in state and local government.

*Dr. Warren C. Stoker, Chairman; Vice President and Dean, Hartford Graduate Center, Rensselaer Polytechnic Institute of Connecticut, Hartford.
*Dr. Hugh Clark, Associate Dean, The Graduate School, University of Connecticut, Storrs.
*Charles H. Coogan, Jr., Professor of Mechanical Engineering, University of Connecticut, Storrs.
Dr. Peter C. Goldmark, President and Director of Research, CBS Laboratories, Stamford.
*Sherman R. Knapp, Chairman of the Board, Northeast Utilities, Wethersfield.
*John G. Lee, Vice Chairman, Board of Regents, University of Hartford, Hartford.
Dr. Thomas F. Malone, Senior Vice President and Director of Research, The Travelers Insurance Company, Hartford.
David B. H. Martin, Hamden, Connecticut.
Henry M. Marx (partner), Kramer, Marx, Greenlee & Backus, Byram.
*Dr. George L. Royer, Administrative Director, Stamford Research Laboratories, American Cyanamid Company, Stamford.

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*Present at meeting of the Connecticut Research Commission on May 8, 1969.

Appendix

Research Support Awards and Contracts Granted by the Connecticut Research Commission

SUMMARY BY CATEGORIES, APRIL 1966 THROUGH DECEMBER 1968

Category	Allocated prior to 1968	Allocated in 1968	Total projects		
			Number	Amount	Percent
A. Increase in research capabilities:					
1. New fields of research	$188,459	$124,227	13	$312,686	11.9
2. Research equipment	345,596	286,499	15	632,095	24.1
3. Aids to research and development	77,166	15,650	4	92,816	3.5
B. Stimulus to economic growth	99,697	47,137	5	146,834	5.6
C. Environmental studies:					
1. Natural resources	76,934	118,421	11	195,355	7.5
2. Air pollution	118,584	83,738	5	202,322	7.8
3. Water pollution	37,450	77,401	4	114,851	4.4
4. Solid waste disposal	27,060	29,250	2	56,310	2.1
5. Noise control	13,625	91,997	3	105,622	4.0
D. Urban and social service problems	44,840	170,261	7	215,101	8.2
E. Transportation studies	0	0		0	
F. Human resources development	11,650	35,516	3	47,166	1.8
G. Effectiveness of governmental operations	119,622	24,906	4	144,528	5.5
H. Communications and information technology	49,624	21,070	2	70,694	2.7
I. Forecasting future changes in Connecticut	0	285,000	2	285,000	10.9
Total	1,210,307	1,411,073	80	2,621,380	100.0

A. Increase in Connecticut Research Capabilities

A–1. NEW FIELDS OF RESEARCH

1967—Histaminopexis: A New Approach to Treatment of Allergies, University of Connecticut, Karl A. Nieforth	$8,240
1968—Application of Electrical Engineering to Neurophysiology, University of Connecticut, Robert B. Northrup	39,698
1967–68 Energy Exchange in Bioluminescence and Other Reactions, New England Institute for Research, J. Lee and S. J. Tao	40,000
1968—Mutants in Mammalian Cell Cultures, Yale University, Richard A. Goldsby	5,600
Lifetimes of Excited Molecular Vibrational States, University of Connecticut, Thomas I. Moran	41,147
Inelastic Atom-Atom Collisions, University of Connecticut, Edward Pollack	18,061
Stereochemistry of Organometallic Compounds, Yale University, J. W. Faller	35,713
Wave Propogation by Direct Finite Element Analysis, University of Connecticut, Herbert A. Koenig	24,953
Photochemical and Spectroscopic Behavior of Rhodopsin Model, Wesleyan University, Peter A. Leermakers	[1] 17,100
Immunological Mechanisms of Avian Leukemia, University of Connecticut, R. A. DiCapua, T. N. Fredrickson, and S. W. Nielson	45,301
Controlled Laser Emission, Yale University, Richard K. Chang	19,175
Problems of Precipitation in the Elimination of Uric Acid, Yale University, Thomas L. Poulson	2,698
Growth, Structure, and Properties of Surface Oxides, Yale University, Gary L. Haller and Arthur Yelon	15,000

[1] Matching grant of $17,100 from National Science Foundation.

A. Increase in Connecticut Research Capabilities—Continued

A–2. RESEARCH EQUIPMENT

1967—Electron Diffraction Study of Surfaces, Yale University, William D. Robertson	$58,790
1967—High Energy Laser Beams, Rensselaer Polytechnic Institute, Helmut J. Schwarz	53,560
1967—Ultraviolet Absorption Spectroscopy in Photochemistry, Yale University, Allan L. Smith	13,825
1968—Digital Data Processing System, University of Connecticut, Taylor L. Booth, David P. Lindorff, and Robert B. Northrup	105,000
1968—Microwave Anechoic Chamber, University of Hartford, William A. Teso	17,000
Mass Spectrometer for Dating Connecticut Rocks, Yale University, R. L. Armstrong and K. K. Turekian	40,000
Infrared Spectroscopy of Ring Molecules, Wesleyan University, Wallace Pringle, Jr.	18,776
Laser-Raman Spectroscopy at High Pressures, University of Bridgeport, James V. Tucci	38,645
Organic Geochemistry of Connecticut Shales and Sediments, St. Joseph College, Sister Mary T. J. Murphy and Sister Maria Clare Markham	20,000
Biochemical Basis of O_2 Requirement, Yale University, Richard A. Goldsby	7,849
Study of Cytochromes and Flavoproteins, University of Connecticut, Philip Strittmatter	150,000
Physiology of Killifish of g. *Fundulus*, Yale University, Grace E. Pickford	1,650
Behavioral Genetics Laboratory, University of Connecticut, Kenneth G. Wilson and Lewis Fox	70,000
LEED and Auger Emission Facilities for Study of Solid Surfaces, Yale University, Traugott E. Fischer	8,000
Improvement of the 20-inch Research Telescope, Wesleyan University, Thornton Page	[2] 29,000

A–3. AIDS TO RESEARCH AND DEVELOPMENT

1968—Attitude and Behavior Patterns in R. & O. Organizations, Yale University, E. E. Lawler III and D. T. Hall	28,688
1968—Compatibility of Research Resources with Research Needs, University Research Institute of Connecticut, Inc., Norman H. Spear	33,182
1968—Directory of Research Laboratories in Connecticut, University Research Institute of Connecticut, Inc. (contract), Norman H. Spear	14,925
Scientific and Technical Information Search, University of Connecticut (NERAC), Samuel I. Doctors and John L. Miller	15,650

B. Stimulus to Economic Growth

1967—Technology to Revitalize Connecticut's Fishing Industry, General Dynamics/Electric Boat, Richard J. Benoit	37,123
1968—Phytoplankton as Food for Oyster Larvae, Yale University, Beatrice M. Sweeney	4,602
1968—Engineering Approaches for Production of Oysters, American Cyanamid Co., D. B. Goodrich and R. B. Wainright	17,894
Materials Processing Research for Metal Working Industries,[3] University of Bridgeport, John T. Berry and David R. Poirier	72,250
Analysis of Bridgeport Regional Economy, Fairfield University, Harry Fishman and Herbert Harris	14,887

[2] Matching grant of $10,750 from National Science Foundation.
[3] Report on 1st year's work in annual report for 1967. Project was extended with additional funds to Dec. 31, 1969.

C. Environmental Studies

C–1. Natural Resources

1968—Wells in a River Valley as a Water Resource, University of Connecticut, Perry H. Rahn	$22, 499
1968—Suitability of Farmington River to Support Shad, University of Connecticut, Walter R. Whitworth	28, 136
1968—Chemistry of a Pine Sawfly, Yale University, W. R. Henson	1, 880
Water Permeation Through Monolayers, University of Connecticut, James Swarbrick	15, 136
Root Exudation and Decline of Connecticut Hardwoods, Yale University, W. H. Smith	2, 569
Connecticut Flora for Tumor Inhibitors, University of Connecticut, Robert E. Willette	10, 797
Absconding Behavior Among Honey Bees, Central Connecticut State College, David C. Newton	7, 514
Reproductive Potential of American Shad in Connecticut River, Essex Marine Laboratory, William C. Leggett	5, 958
Allelopathy in Vegetation Dynamics of New England, Yale University, F. H. Bormann	8, 907
Upper Triassic Dinosaurs of Conecticut Valley, Yale University, Alfred W. Crompton and John H. Ostrom	13, 000
Marine Mineral Identification Survey in Long Is land Sound, United Aircraft Research Laboratories, J. Leslie Goodier	78, 342

C–2. Air Pollution

1967—Computer Simulation Model for Air Pollution, Travelers Research Center, Inc., Glenn R. Hilst	94, 635
1968—Laboratory Model of Gas Analyzer, Trinity College, H. A. DePhillips, Jr., M. E. McCormick, and T. J. Schmugge	12, 627
Analysis for Nitrogen Oxides by Ultraviolet Spectrophotometry, Fairfield University, John C. MacDonald	11, 322
Venturi Type Air Pollution Control Device, University of Bridgeport, Edward S. Tillman, Jr	21, 538
Verification and Refinement of Connecticut Air Pollution Simulation Model, Travelers Research Corp. (contract), George D. Robinson	[4] 62, 200

C–3. Water Pollution

1968—Feasibility Study of Means of Disposal of Liquid Industrial Wastes, James S. Mingers & Associates (contract), Charles A. Jaworski	33, 000
Feasibility Study of Oil Spill Control Facility, Essex Marine Laboratory, Inc., William A. Boyd	2, 250
Treatment of Brass Mill Effluents, Anaconda American Brass Co., Oliver P. Case	66, 836
Effects of RF Fields on Sedimentation Rates of Suspensoids, New England Institute, James H. Green	10, 565

C–4. Solid Waste Disposal

1967–68—New Solid Waste Disposal System, University of Hartford, A. C. Eggen and O. A. Powell, Jr	27, 060
Collection and Disposal of Abandoned Motor Vehicles, University of Hartford, Edward F. McDonough	29, 250

C–5. Noise Control

1968—Mobile Noise Measurement Laboratory, University of Hartford. Conrad J. Hemond, Jr	13, 625
Highway Noise Measurement Survey, CBS Laboratories (contract), Benjamin B. Bauer	27, 100
Portable Noise Instrument, CBS Laboratories (contract), Benjamin B. Bauer	64, 897

[4] Matched by a grant of $186,590 from National Air Pollution Control Administration.

D. Urban and Social Service Problems

1967—Child Welfare Needs and Resources, University Research Institute of Connecticut, Inc., Norman H. Spear	$13,056
1967—Socio-Economic Factors in Mental Health Services, State Mental Health Department, S. Kligerman and D. Prosser	21,934
1968—Preliminary Systems Analysis of Rat Control Measures, Meyers Electro/Cooling Products, Inc. (contract), Peter G. Meyers	9,850
Inner City in Crisis, University of Connecticut, Irving L. Allen and J. David Colfax	26,614
Maturity and Guilt in Delinquent Boys, University of Connecticut, Herbert J. Cross	13,022
Identification of Consumer Resources in Connecticut, University of Connecticut, Thomas M. Brooks and Elsie Fetterman	6,000
Modular Prefabricated Housing Feasibility Study, Arthur D. Little (contract), Robert D. Graff	124,625

E. Transportation Studies

No projects were initiated prior to 1969.

F. Human Resources Development

1967—On-the-Job Training Through Educational Television, Connecticut Educational TV Corp., Robert B. Bergeron	11,650
Reading and Psychomotor Disability Among Mentally Handicapped and Average Children, University of Connecticut, John F. Cawley	32,116
Computer Assisted Math Instruction, COSSECC, D. Edward Mas	3,400

G. Effectiveness of Governmental Operations

1967—Information-Handling Service for Regional Government, University of Connecticut, Myron E. Weiner	34,532
Inter-Municipal Information-Handling Service for Connecticut Municipal Governments and School Systems, University of Conecticut, Myron E. Weiner	14,906
R. & D. Applied to Police Departments in Connecticut Cities, Travelers Research Corp., Frank J. Leahy, Jr.	84,652
Revision of Connecticut's Succession and Estate Tax Laws, Probate Administration, Robert Whitman	10,000

H. Communications and Information Technology

1966—Plan for a Connecticut Library Research Center, UAC Corporate Systems Center, James A. Ockenden	49,624
Science, Technology and Law: A Survey and Program, University of Connecticut, Philip Shuchman	21,070

I. Forecasting Future Changes in Connecticut

Influence of Technological Innovation on the Future of Connecticut, Rensselaer Polytechnic Institute of Connecticut, Inc. (contract for technical planning of the conference held on Oct. 13–15, 1968), Spencer J. Hayden	35,000
Long-Range Technological and Economic Developments, Institute for the Future, Olaf Helmer	250,000

(Whereupon, at 12:05 p.m. the subcommittee adjourned subject to the call of the Chair.)

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